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(54) Title: TROPOELASTIN DERIVATIVES

(57) Abstract

The invention relates to derivatives of tropoelastin and variants of those derivatives. The invention further provides expression products and hybrid molecules of the derivatives and variants of the invention. The invention further provides methods for the production of the derivatives, variants, expression products and hybrid molecules. Further provided are formulations, cross-linked structures and implants comprising the derivatives, variants, expression products and hybrid molecules of the invention. Further provided are uses of the derivatives, variants, expression products and hybrid molecules of the invention.

TROPOELASTIN DERIVATIVES

TECHNICAL FIELD

The present invention relates to derivatives of human tropoelastin and variants thereof, to genetic constructs encoding the amino acid sequences of the derivatives and variants and to uses of the derivatives and variants. In particular, the derivatives of the present invention have elastin-like properties or macro-molecular binding properties.

BACKGROUND ART

There are various forms of tropoelastin that typically appear to consist of two types of alternating domains: those rich in hydrophobic amino acids (responsible for the elastic properties) and those rich in lysine residues (responsible for cross-link formation). Hydrophobic and cross-linking domains are encoded in separate exons (Indik *et al* 1987).

The 26 A region of human tropoelastin is unique amongst tropoelastin domains in that, due to the absence of lysine, this region does not participate in elastin cross-link formation. Furthermore, this region is a serine-rich domain and lacks hydrophobic stretches, indicating that it is unlikely to contribute to the elasticity of tropoelastin. There is otherwise limited information on the structure and functional relationships of the 26 A region (Bedell-Hogan *et al.*, 1993).

The gene for tropoelastin is believed to be present as a single copy in the mammalian genome, and is expressed in the form of multiple transcripts, distinguished by alternative splicing of the pre-mRNA (Indik *et al*, 1990; Oliver *et al*, 1987). Modest expression of a natural human tropoelastin sequence has been achieved by Indik *et al* (1990) using cDNA, providing free polypeptide which unfortunately was unstable.

Expression of substantial amounts of human tropoelastin using synthetic polynucleotides is reported

in WO94/14951. In particular a construct [illegible] providing substantial amounts of full length human tropoelastin is described.

DESCRIPTION OF THE INVENTION

In the specification and claims, "derivatives of human tropoelastin" or "tropoelastin derivatives" means novel peptides, polypeptides or proteins which contain amino acid sequences derived from the native amino acid sequences of human tropoelastin molecules. The amino acid sequences of the derivatives of human tropoelastin may be derived from any of the amino acid sequences of the isoforms of human tropoelastin. Derivatives of human tropoelastin are distinguished from human tropoelastin molecules in that the amino acid sequences of derivatives are altered with respect to native tropoelastin sequences by substitution, addition or deletion of residues or a combination of these alterations, in derivative amino acid sequences.

In a first aspect, the present invention provides derivatives of human tropoelastin which have elastin-like properties. Elastin-like properties are a combination of elastic properties, including the phenomenon of recoil following molecular distention under appropriate conditions, and the ability to be cross-linked to other elastin molecules and/or other elastin-like molecules.

In a second aspect, the present invention provides derivatives of human tropoelastin which have macro-molecular binding properties including the ability to bind glycosaminoglycans.

In a third aspect, the present invention provides derivatives of human tropoelastin which have elastin-like properties and macro-molecular binding properties.

The present invention further provides amino acid sequence variants of the derivatives of the invention. In the specification and claims "variants" means amino acid sequences which retain the properties of the corresponding derivative of human tropoelastin, for example, elastin-

like properties or macro-molecular binding properties, or a combination of elastin-like properties and macro-molecular binding properties, and have an amino acid sequence which is homologous with the amino acid sequence of the corresponding derivative. For the purposes of this description, "homology" between the amino acid sequence of a particular derivative of human tropoelastin and another amino acid sequence connotes a likeness short of identity, indicative of a derivation of one sequence from the other. In particular, an amino acid sequence is homologous to a derivative of human tropoelastin if the alignment of that amino acid sequence with the sequence of the derivative of human tropoelastin reveals a similarity of about 65% over any 20 amino acid stretch or over any repetitive element of the molecules shorter than 20 amino acids in length. Such a sequence comparison can be performed via known algorithims, such as that of Lipman and Pearson (1985). Similarity is observed between amino acids where those amino acids have a side chain which confers a similar chemical property in the same chemical environment. For example, threonine and serine are similar amino acids; aspartic acid and glutamic acid are similar amino acids; valine, leucine and isoleucine are similar amino acids etc. Thus, an amino acid sequence may be considered homologous with the amino acid sequence of a human tropoelastin derivative because the alignment of those sequences reveals a similarity of 65%, although at each amino acid position in the aligned sequences, none of the residues are identical.

Inasmuch as the present invention provides derivatives of human tropoelastin and amino acid sequence variants of those derivatives, the invention thus extends to amino acid sequence variants incorporating amino acid sequences of non-human tropoelastins. Amino acid sequence variants which are non-human tropoelastin derivatives, or are based all, or in part, on non-human tropoelastin derivatives retain properties of the corresponding

[illegible] like properties [illegible] properties, [illegible] and macro-molecular binding properties, and have an amino acid sequence which is homologous with the amino acid sequence of the corresponding human derivative. The variants of the invention also include variants of the non-human tropoelastin derivatives, or of derivatives based on the non-human tropoelastin derivatives. "Homology" between the amino acid sequence of a particular derivative of non-human tropoelastin and another amino acid sequence connotes a likeness short of identity, indicative of a derivation of one sequence from the other. In particular, an amino acid sequence is homologous to a derivative of non-human tropoelastin if the alignment of that amino acid sequence with the sequence of the derivative of non-human tropoelastin reveals a similarity of about 65% over any 20 amino acid stretch or over any repetitive element of the molecules shorter than 20 amino acid in length. The skilled addressee will understand that species that are substantially phylogenetically related to humans express tropoelastin molecules which consist of amino acid sequences with homology to human tropoelastin amino acid sequences. Indeed, amino acid sequences of non-human tropoelastins have been determined, including the amino acid sequences of chick tropoelastin, bovine tropoelastin and rat tropoelastin (Bressan *et al.* 1987, Raju *et al.* 1987, Pierce *et al.* 1992) and over multiple regions, these are homologous with the human tropoelastin amino acid sequences. The skilled addressee will recognise therefore, that derivatives of human tropoelastin and amino acid sequence variants of those derivatives will necessarily encompass corresponding tropoelastin amino acid sequences from these and other non-human species.

The present invention provides a tropoelastin derivative comprising the amino acid sequence of SHELδmodified (SEQ ID NO:5). The amino acid sequence of

SHELδmodified and the alignment of that amino acid sequence with the human tropoelastin sequence is shown in Figure 5.

The invention also provides an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELδmodified.

The invention also provides a polynucleotide encoding a tropoelastin derivative comprising the amino acid sequence of SHELδmodified. The nucleotide sequence encoding SHELδmodified is shown in Figure 3 (SEQ ID NO: 4). Preferably the polynucleotide comprises the nucleotide sequence which corresponds to SHELδmodified shown in Figure 3.

The invention also provides a polynucleotide encoding an amino acid sequence variant of the derivative SHELδmodified.

The present invention further provides a synthetic polynucleotide encoding a tropoelastin derivative comprising the amino acid sequence of SHELδ26A (SEQ ID NO:3). A synthetic polynucleotide is a molecule which comprises a nucleotide sequence that contains silent mutations with respect to the corresponding native polynucleotide molecule. The silent mutations enhance the expression of the synthetic polynucleotide. The amino acid sequence of SHELδ26A and the alignment of that amino acid sequence with the human tropoelastin sequence is shown in Figure 2. The SHELδ26A derivative excludes the SHEL coding sequence corresponding to exon 26A. Preferably the synthetic polynucleotide comprises the sequence shown in Figure 1 (SEQ ID NO:1) from nucleotide position 1 to 1676 contiguous with nucleotide position 1775 to 2210.

The invention also provides a polynucleotide encoding an amino acid sequence variant of the derivative SHELδ26A.

The invention also provides an amino acid sequence

variant of the derivative comprising the amino acid sequence of SHELδ26A.

The present inventor has, for the first time, shown that the region encoded by exon 26A (peptide 26A) of the tropoelastin gene binds glycosaminoglycans (GAGs) (Figure 6A and B). GAGs are macro-molecules particularly associated with the extracellular environment. These molecules play an important role in the architecture and mechanical properties of connective tissues and mediate interactions with and availability of other molecules.

Thus, the present invention provides a tropoelastin derivative comprising the amino acid sequence of peptide 26A. Peptide 26A has the amino acid sequence: GADEGVRRSLSPELREGDPSSSQHLPSTPSSPRV (SEQ ID NO: 12) or GADEGVRRSLSPELREGDPSSSQHLPSTPSSPRF (SEQ ID NO: 13). claim 77 claims 57, 58, 64, 65

The present invention also provides an amino acid sequence variant of the derivative comprising the amino acid sequence of peptide 26A.

The invention also provides a polynucleotide encoding a tropoelastin derivative comprising the amino acid sequence of peptide 26A. Preferably the polynucleotide comprises the nucleotide sequence shown in Figure 1 (SEQ ID NO: 1) from nucleotide position 1687 to 1778. Preferably the 3' terminal codon is GTT (which encodes V) or TTT (which encodes F).

The invention also provides a polynucleotide encoding an amino acid sequence variant of the derivative comprising the amino acid sequence of peptide 26A.

In appreciating the GAG binding property of peptide 26A, the present inventor envisages the generation of novel subsets of hybrid molecules, comprising biological polymers which are linked to peptide 26A, wherein the peptide 26A imparts GAG binding activity to the polymer. In particular, the present inventor has recognised that the deletion or insertion of the peptide 26A amino acid sequence, or a variant of that amino acid sequence will alter GAG binding activity. Thus, the present invention relates to tropoelastin derivatives in which full length

or partial length tropoelastin molecules have been modified by the addition of one or more exon 26A regions to enhance interactions with GAGs. Moreover, the invention relates to site directed modification of the amino acid sequence of peptide 26A so as to generate variants of the peptide 26A amino acid sequence which have altered affinity or altered specificity for GAGs. Tropoelastin derivatives or variants of the derivatives which contain altered GAG binding activity may be uncross-linked or cross-linked.

In another aspect, the invention provides a hybrid molecule. In the specification and claims, "hybrid molecule" means a molecule comprising a biological polymer which is linked to a tropoelastin derivative comprising the amino acid sequence of peptide 26A or an amino acid sequence variant of a derivative comprising the amino acid sequence of peptide 26A. Preferably the biological polymer is a protein. More preferably the protein is selected from the group consisting of growth factors, cytokines and antibodies. Alternatively the biological polymer is selected from the group consisting of lipids, sugars or nucleic acids.

In one embodiment, and where the biological polymer is a protein, the hybrid molecule is produced by recombinant DNA techniques, including for example the construction of a nucleotide sequence which encodes the biological polymer and the tropoelastin derivative comprising the amino acid sequence of peptide 26A, or the amino acid sequence variant of a derivative comprising the amino acid sequence of peptide 26 A, in a single open reading frame. Alternatively, the hybrid molecule may be produced synthetically by solid phase peptide synthesis, including, for example the methods of synthesis disclosed in Merrifield (1963) or Knorr *et al.* (1989). Examples of peptide synthesis also include the synthesis methods used by peptide synthesisers of Perkin Elmer/Applied Biosystems, CA, US.

In another aspect, the invention provides a

polynucleotide sequence encoding a hybrid molecule of the invention.

In another aspect, the invention provides a hybrid molecule which comprises a synthetic polymer which is linked to a tropoelastin derivative comprising the amino acid sequence of peptide 26A, or an amino acid sequence variant of the derivative comprising the amino acid sequence of peptide 26A.

The invention further provides a method of imparting or enhancing GAG binding activity to a biological polymer comprising the step of linking a tropoelastin derivative comprising the amino acid sequence of peptide 26A, or an amino acid sequence variant of peptide 26A with the biological polymer. Preferably the biological polymer is a protein.

The invention further provides a method of deleting or reducing GAG binding activity from a biological polymer comprising the step of deleting a tropoelastin derivative comprising the amino acid sequence of peptide 26A, or an amino acid sequence variant of peptide 26A from the biological polymer. Preferably the biological polymer is a protein.

The present invention also provides a tropoelastin derivative comprising the amino acid sequence of SHELgamma. SHELgamma has the amino acid sequence:
SAMGALVGLGVPGLGVGAGVPGFGAGADEGVRRSLSPELREGDPSSSQHLPSTPSSPR
VPGALAAAKAAKYGAAVPGVLGGLGALGGVGIPGGVVGAGPAAAAAAAKAAAKAAQFG
LVGAAGLGGLGVGGLGVPGVGGLGGIPPAAAAKAAKYGAAGLGGVLGGAGQFPLGGVA
ARPGFGLSPIFPGGACLGKACGRKRK (SEQ ID NO: 9).

The invention also provides an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELgamma.

The invention also provides a polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of SHELgamma. The nucleotide sequence of the polynucleotide SHELgamma (SEQ ID NO: 8) is shown in Figure 8. In this nucleotide sequence, the first 9 codons from nucleotide position 948 to 974 are derived

from the glutathione S-transferase (GST) fusion nucleotide sequence. Preferably the polynucleotide comprises the nucleotide sequence shown in Figure 5. More preferably the polynucleotide comprises the nucleotide sequence shown in Figure 5 from nucleotide sequence position 975 to 1547.

The invention also provides a polynucleotide encoding an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELgamma.

The present invention also provides a polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of SHELgamma excluding exon 26A. The nucleotide sequence of the polynucleotide SHELgamma excluding exon 26A (SEQ ID NO: 6) is shown in Figure 7. In this nucleotide sequence, the first 5 codons from nucleotide position 948 to 962 are derived from the GST nucleotide sequence. SHELgamma excluding exon 26A has the following amino acid sequence:

Claims 57, 66, 67, 68 & 29, 26, 23

VPGALAAAKAAKYGPAVPGVLGGLGALGGVGIPGGVVGAGPAAAAAAAAKAAAKAAQFG
LVGAAGLGGLGVGGLGVPGVGGLGGIPPAAAAKAAKYGAAGLGGVLGGAGQFPLGGVA
ARPGFGLSPIFPGGACLGKACGRKRK (SEQ ID NO: 7).

Preferably the polynucleotide comprises the nucleotide sequence shown in SEQ ID NO:6. More preferably the polynucleotide comprises the nucleotide sequence shown in SEQ ID NO: 6 from nucleotide sequence position 15 to 441.

The invention also provides a polynucleotide encoding an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELgamma excluding exon 26A.

The invention also provides a tropoelastin derivative comprising the amino acid sequence of SHELgamma excluding exon 26A.

The invention also provides an amino acid sequence variant of the derivative comprising SHELgamma excluding exon 26A.

The derivatives of the invention based on SHELgamma can also be produced by *in vitro* biochemical cleavage of tropoelastin products such as SHEL, so as to release a carboxy- terminal fragment. The carboxy-terminal fragment

may be purified by reverse phase HPLC.

The present invention also provides a tropoelastin derivative comprising the amino acid sequence of SHEL31-36. SHEL31-36 has the following amino acid sequence: GIPPAAAAHAAKYGAAGLGGVLGGAGQFPLGGVAARPGFGLSPIFPGGACLGKACG-RKRK (SEQ ID NO: 10).

SHEL31-36 retains a crosslinking domain. As a consequence of its elastin-like properties, it is envisaged that this and related tropoelastin derivatives can be used to interfere with tropoelastin deposition and formation of unaltered elastic fibre.

The invention also provides an amino acid sequence variant of the derivative comprising the amino acid sequence of SHEL31-36.

The invention also provides a polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of SHEL31-36. Preferably the polynucleotide comprises the nucleotide sequence shown in Figure 1 (SEQ ID NO:1) from nucleotide position 2032 to 2210.

The invention also provides a polynucleotide encoding an amino acid variant of the derivative comprising the amino acid sequence of SHEL31-36.

The present invention also provides a tropoelastin derivative, comprising the amino acid sequence of SHEL32-36. SHEL32-36 has the following amino acid sequence: GAAGLGGVLGGAGQFPLGGVAARPGFGLSPIFPGGACLGKACGRKRK (SEQ ID NO: 11).

The invention also provides an amino acid sequence variant of the derivative comprising the amino acid sequence of SHEL32-36.

The invention also provides a polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of SHEL32-36. Preferably the polynucleotide comprises the nucleotide sequence shown in Figure 1 (SEQ ID NO: 1) from nucleotide position 2061 to 2210.

The present invention also provides a polynucleotide

encoding an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELI-36.

As a consequence of the elastin-like properties, it is envisaged that SHELI-36 and related tropoelastin derivatives can be used to interfere with tropoelastin deposition and formation of an unaltered elastic fibre.

The present invention also provides a tropoelastin derivative comprising the amino acid sequence of SHELI-36. SHELI-36 has the following amino acid sequence:

AAAGLGAGIPGLGVGVGVPGLGVGAGVPGLGVGAGVPGFGAGADFGVRRSLSFELREIT PSSSQHLPSTPSSPRVPGALAAAKAAAYGAAVPGVLGGLGALGGVGIPGGVTGAGPAAA AAAAKAAAKAAQFGLVGAAGLGGLGVGGLGVPGVGGLGGIPPAAAAKAAAYGAAGLGGV LGGAGQFPLGGVAARPGFGLSPIFPGGAGLGVAGGRKRK SEQ ID NO: 14

The invention also provides an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELI-36.

The invention also provides a polynucleotide encoding a tropoelastin derivative the derivative comprising the amino acid sequence of SHELI-36. Preferably the polynucleotide comprises the nucleotide sequence shown in Figure 1 from nucleotide position 1554 2211.

The present invention also provides a tropoelastin derivative, comprising the amino acid sequence of SHELI-36 excluding exon 26A. SHELI-36 excluding exon 26A has the following amino acid sequence:

AAAGLGAGIPGLGVGVGVPGLGVGAGVPGLGVGAGVPGFGAGADFGVRRSLSFELREIT PSSSQHLPSTPSSPRVPGALAAAKAAAYGAAVPGVLGGLGALGGVGIPGGVTGAGPAAA AAAAKAAAKAAQFGLVGAAGLGGLGVGGLGVPGVGGLGGIPPAAAAKAAAYGAAGLGGV LGGAGQFPLGGVAARPGFGLSPIFPGGAGLGVAGGRKRK (SEQ ID NO: 15)

The invention also provides an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELI-36 excluding exon 26A.

The invention also provides a polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of SHELI-36 excluding exon 26A. Preferably the polynucleotide comprises the nucleotide sequence shown in Figure 1 from nucleotide position [illegible]

to 167 contiguous with 177 to 211.

The present invention also provides a polynucleotide encoding an amino acid sequence variant of the derivative comprising the amino acid sequence of SHEL26-36.

In another aspect the present invention provides a formulation comprising a tropoelastin derivative, a variant of the derivative or a hybrid molecule of the invention together with a carrier or diluent.

Formulations of the derivatives, variants or hybrid molecules of the invention can be prepared in accordance with standard techniques appropriate to the field in which they are to be used.

The polynucleotides and synthetic polynucleotides of the invention can be provided in association with other polynucleotide sequences including 5' and 3' untranslated sequences, and 5' upstream and 3' downstream transcriptional regulatory sequences. The polynucleotides and synthetic polynucleotides may be provided as a recombinant DNA molecule including plasmid DNA.

The polynucleotides and synthetic polynucleotides of the invention can be prepared using the techniques of chemical synthesis or recombinant DNA technology, or by a combination of both techniques.

In a further aspect the invention provides a vector comprising a polynucleotide or synthetic polynucleotide encoding a tropoelastin derivative, a variant of the derivative or a hybrid molecule of the invention.

Vectors useful in this invention include plasmids, phages and phagemids. The polynucleotides and synthetic polynucleotides of the present invention can also be used in integrative expression systems or lytic or comparable expression systems.

Suitable vectors will generally contain origins of replication and control sequences which are derived from species compatible with the intended expression host. Typically these vectors include a promoter located upstream from the polynucleotide, together with a ribosome binding site if intended for prokaryotic expression and a

phenotypic selection gene such as one conferring antibiotic resistance or supplying an auxotrophic requirement. For production vectors, vectors which provide for enhanced stability through partitioning may be chosen. Where integrative vectors are used it is not necessary for the vector to have an origin of replication. Lytic and other comparable expression systems do not need to have those functions required for maintenance of vectors in hosts.

For *E. coli* typical vectors include pBR322, pBluescript II SK', pGEX-2T, pTrc99A, pET series vectors, particularly pET3d, (Studier *et al.*, 1990) and derivatives of these vectors. Derivatives include those plasmids with a modified protease recognition sequence to facilitate purification of a protein domain.

In another aspect the invention provides a cell capable of expressing a polynucleotide or a synthetic polynucleotide which encodes a derivative or variant of the invention, or a polynucleotide which encodes a hybrid molecule of the invention.

A preferred expression system is an *E. coli* expression system. However, the invention includes within its scope the use of other hosts capable of expressing protein from the polynucleotides designed for use in *E. coli*. The invention also includes the use of polynucleotides and synthetic polynucleotides suitable for use in other expression systems such as other microbial expression systems. These other expression systems include yeast, and bacterial expression systems, insect cell expression systems, and expression systems involving other eukaryotic cell lines or whole organisms.

Examples of *E. coli* hosts include *E. coli* B strain derivatives (Studier *et al*, 1990), and K-strain derivatives such as NM522 (Gough and Murray, 1983) and XL1-Blue (Bullock *et al*, 1987).

In a further aspect the present invention provides an expression product. In the specification and claims, "expression product" means a derivative or variant of the

invention expressed by a cell containing a polynucleotide or a synthetic polynucleotide encoding a derivative or variant of the invention.

The expression products of the invention may be fused expression products which include all or part of a protein encoded by the vector in peptide linkage with the derivative or variant. They may also include, for example, an N-terminal methionine or other additional residues which do not permanently impair the elastin-like, or macro-molecular binding properties of the product.

Typically the fusion is to the N-terminus of the expression product. An example of a suitable protein is to the C-terminus of glutathione *S*-transferase. The fused protein sequence may be chosen in order to cause the expression product to be secreted or expressed as a cell surface protein to simplify purification or expressed as a cytoplasmic protein.

The expressed fusion products may subsequently be treated to remove the fused protein sequences to provide free tropoelastin derivative or variant. Treatment is typically through protease treatment or, in the case of secretion, removal is effected by endogenous host secretion machinery. An example of this is secretion by yeasts.

Non-fused systems include the introduction of or use of a pre-existing methionine codon. An example of this is the use of pET3a or pET3d in *E. coli*.

In another aspect the invention provides a polynucleotide encoding an expression product of the invention.

In another aspect the present invention provides a formulation comprising an expression product of the invention together with a carrier or diluent. The formulation of the expression product can be prepared in accordance with standard techniques appropriate to the field in which they are to be used.

According to a further aspect of the present invention there is provided a method for producing a

tropoelastin derivative or a variant of the derivative comprising providing a vector containing a polynucleotide or a synthetic polynucleotide encoding the derivative or variant; introducing the vector into a suitable host cell; maintaining the cell in conditions suitable for expression of the polynucleotide or synthetic polynucleotide and isolating the derivative or variant of the invention. The method can be applied to the production of the expression products and hybrid molecules (in which the hybrid molecules comprise the peptide 26A or a variant thereof and a further amino acid sequence) of the invention, by providing a vector containing a polynucleotide encoding an expression product or a hybrid molecule; introducing the vector into a suitable host cell; maintaining the cell in conditions suitable for expression of the polynucleotide and isolating the expression product or hybrid molecule.

In one embodiment, the polynucleotide or synthetic polynucleotide encoding the derivative, variant, expression product or hybrid molecule of the invention is expressed in a host cell which is maintained in culture *in vitro*.

Alternatively, the polynucleotide or synthetic polynucleotide encoding the derivative, variant, expression product or hybrid molecule of the invention is expressed in a host cell which is maintained *in vivo*. Thus, in another embodiment, the polynucleotide or synthetic polynucleotide encoding the derivative, variant, expression product or hybrid molecule of the invention is expressed in a transgenic animal. Methods for the generation of transgenic animals are known in the ar Exemplary methods are described in Slack et al. 1991 and Janne et al. 1992.

The tropoelastin derivatives, variants of the derivatives, and hybrid molecules (in which the hybrid molecules comprise the peptide 26A or a variant thereof and a further amino acid sequence) of the invention may be produced by solid phase peptide synthesis, including, for

described in Merrifield

(1963) or Knorr *et al* (1989). Examples of peptide synthesis also include the synthesis methods used by peptide synthesisers of Perkin Elmer/Applied Biosystems, CA, US. As an alternative to cell synthesis from a polynucleotide or synthetic polynucleotide, the expression products of the invention may be produced by solid phase peptide synthesis.

In a further aspect the present invention provides an implant formed from at least one tropoelastin derivative and/or variant of the derivative of the invention. The implant may alternatively contain at least one expression product and/or at least one hybrid molecule of the invention.

The implants are formed into the required shape by cross-linking the tropoelastin derivative, variant of the derivative, expression product, or hybrid molecule of the invention, in a mould which conforms to the desired shape of the implant. Where the implant is required to be used in sheet form the tropoelastin derivative, variant of the derivative, expression product, or hybrid molecule of the invention can be cross-linked on a flat surface. Relevant methodologies are described in, for example, US Patent No. 4 474 851 and US Patent No. 5 250 516. The elastomeric materials may be exclusively prepared from one or more tropoelastin derivatives, variants of the derivative, expression products, or hybrid molecules of the invention or may be composites prepared from one or more of these constituents together with other materials.

The tropoelastin derivatives or variants of the derivatives can be cross linked to form elastin or elastin-like material or can be cross-linked in conjunction with other biological or synthetic molecules to form a composite material.

Thus in another aspect the invention provides a cross-linked complex which comprises at least one tropoelastin derivative of the invention and/or at least one variant of a derivative of the invention. The cross-linked complexes may additionally contain at least one

expression product and/or at least one hybrid molecule of the invention, which may be cross-linked to the at least one tropoelastin derivative and/or variant of the derivative of the invention.

The cross-linking of the tropoelastin derivatives, variants of the derivatives, hybrid molecules and expression products of the invention can be achieved by chemical oxidation of lysine side chains using processes such as ruthenium tetroxide mediated oxidation and quinone mediated oxidation, or by using homobifunctional chemical cross-linking agents such as dithiobis (succinimidylpropionate), dimethyl adipimidate or dimethyl pimelimidate. Glutaraldehyde cross-linking is an important addition to this repetoire. Another alternative is the cross-linking of lysine and glutamic side chains.

The tropoelastin derivatives, variants of the derivatives, hybrid molecules and expression products of the invention may also be enzymatically cross-linked by methods including lysyl oxidase mediated oxidation or may be cross-linked using gamma irradiation.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1: Nucleotide (SEQ ID NO: 1) and predicted amino acid (SEQ ID NO:2) sequences of synthetic human tropoelastin SHEL. The upper (numbered) nucleotide sequence represents the coding strand.

Figure 2: Alignment of SHEL (SEQ ID NO:2)(upper line) and SHELδ26A (SEQ ID NO: 3) amino acid sequences.

Figure 3: Nucleotide (SEQ ID NO: 4) and predicted amino acid (SEQ ID NO: 5) sequences of SHELδmodified.

Figure 4: Alignment of SHELδmodified (SEQ ID NO: 4) (upper line) and SHEL (SEQ ID NO:1) nucleotide sequences.

Figure 5: Alignment of SHELδmodified (SEQ ID NO: 5)(lower line) and SHEL (SEQ ID NO: 1) amino acid sequences.

Figure 6A: HPLC elution profile of GST-exon 26A fusion protein tropoelastin derivative loaded in from

heparin sepharose. 6B: Binding of peptide 26A (SEQ ID NO: 12 and SEQ ID NO: 13) to glycosaminoglycans.

Figure 7: Nucleotide (SEQ ID NO: 6) and predicted amino acid (SEQ ID NO: 7) sequences of SHELgamma excluding exon 26A.

Figure 8: Nucleotide (SEQ ID NO: 8) and predicted amino acid (SEQ ID NO: 9) sequences of SHELgamma.

BEST METHOD OF PERFORMING THE INVENTION

The recombinant and synthetic procedures used for the synthesis of the derivatives, variants, expression products and hybrid molecules of the invention are described in standard texts such as Sambrook et al (1989).

Tropoelastin nucleotide sequences may be modified so as to provide derivatives, variants, expression products or hybrid molecules, by conventional site-directed or random mutagenesis. The sequences may also be modified by oligonucleotide-directed mutagenesis, which comprises the following steps:

1. synthesis of an oligonucleotide with a sequence that contains the desired nucleotide substitution (mutation);
2. hybridising the oligonucleotide to a template comprising a structural sequence encoding tropoelastin; and
3. using a DNA polymerase to extend the oligonucleotide as a primer.

Another approach which is particularly suited to situations where a synthetic polynucleotide encoding the tropoelastin derivative is prepared from oligonucleotide blocks bounded by restriction sites, is cassette mutagenesis where entire restriction fragments are replaced.

Purification of the derivatives, variants, expression products or hybrid molecules of the invention is performed using standard techniques including HPLC. The actual sequence of steps in the purification of a particular derivative, variant, expression product or hybrid molecule

is limited by the environment from which the molecule is to be purified. By way of example, reference is made to the purification scheme disclosed in WO94/14955.

Formulations in accordance with the invention are formulated in accordance with standard techniques.

The amount of derivative, variant, expression product or hybrid molecule that may be combined with a carrier or diluent to produce a single dosage will vary depending on the situation in which the formulation is to be used and the particular mode of administration.

It will be understood also that specific doses for any particular host may be influenced by factors such as the age, sex, weight and general health of the host as well as the particular characteristics of the derivative, variant, expression product or hybrid molecule of the invention being used, and how it is administered.

Injectable preparations, for example, sterile injectable aqueous or oleagenous suspensions may be formulated according to the known art using suitable dispersing or wetting agents and suspending agents. The sterile injectable preparation may also be a sterile injectable solution or suspension in a non-toxic parenterally acceptable diluent or solvent. Among the acceptable vehicles or solvents that may be employed are water, Ringer's solution, alcohols and isotonic sodium chloride solution. In addition, sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil may be employed including synthetic mono- or diglycerides. In addition, fatty acids such as oleic acid and organic solvents find use in the preparation of injectables.

Routes of administration, dosages to be administered as well as frequency of administration are all factors which can be optimised using ordinary skill in the art.

In addition, the derivatives, variants, expression products and hybrid molecules of the invention may be prepared as topical preparations for instance as anti-wrinkle and hand lotions using standard techniques for the

preparation of such formulations. They may be prepared in aerosol form for, for instance, administration to a patient's lungs, or in the form of surgical implants, foods or industrial products by standard techniques.

SHEL

The preparation of SHEL is described in WO94 14958. It is directly expressed as a full length human protein with a calculated molecular weight of 64kDa. The full nucleotide sequence and corresponding amino acid sequence of SHEL is shown in Figure 1. The preparation of pSHELF is described in WO94/14958.

pSHELF differs from the natural coding sequence(s) in a number of ways. As described in WO94 14958, the untranslated regions present in the tropoelastin cDNA sequence were disregarded in designing the synthetic gene, and the nucleotides encoding the signal peptide were removed. Restriction endonuclease recognition sites were incorporated at regular intervals into the gene by typically altering only the third base of the relevant codons, thereby maintaining the primary sequence of the gene product. The facility for silent alteration of the coding sequence was also exploited to change the codon bias of the tropoelastin gene to that commonly found in highly expressed *E.coli* genes. [Genetics Computer Group (GCG) package version 7-UNIX using Codon Frequency and Gen Run Data: ecohigh-cod]. Two additional stop codons were added to the 3'-end, and an ATG start codon comprising a novel NcoI site was appended to the 5'-end. *Bam* HI cloning sites were engineered at both ends of the synthetic sequence. Since the gene contains no internal methionine residues, treatment of the newly-synthesized gene product (expressed directly or as a fusion with another gene) with cyanogen bromide would liberate a protein with the same or similar sequence as one form of natural tropoelastin comprising 731 amino acids. Other forms of processing are envisaged, which may generate tropoelastin species of the same or different lengths

Two stop codons were added in order to allow the possible use of the construct in suppressor hosts, and also to avoid any potential depletion of termination (release) factors for translation.

As described in the following examples, the derivatives, pSHELFδ26A, pSHELFδ modified, pSHELgamma, pSHEL31-36, pSHEL32-36 and pSHELgammaδ26A were derived from the pSHELF nucleotide sequence. These particular derivatives, and indeed the derivaties, variants, expression products and hybrid molecules of the invention can equally be derived from a native human or non -human tropoelastin nucleotide sequence.

Example 1: Construction of pSHELFδ26A and pSHELFδ modified

Mutagenesis was used with pSHELF to remove DNA corresponding to exon 26A. The sequence of the mutagenic primer was:

5'CGG GTT TCG GTG CTG TTC CGG GCG CGC TGG 3'

This flanked either side of exon 26A by 15bp resulting in its precise deletion. A second selection primer, which mutates a unique restriction site to another restriction site is normally used in the protocol but was not in this case since deletion of exon 26A also resulted in the deletion of a unique restriction site, *PmlI*. The enzyme *PmlI* was used to treat the mutation reaction to linearise any unmutated parental plasmid and consequently to enrich for mutant plasmid. The reaction mixture was used to transform competent BMH17-18 *mutS E. coli*, defective in mismatch repair, by electroporation and the entire transformed culture was grown overnight in LB+ampicillin. Mixed plasmid DNA, containing both mutated and parental plasmids, was isolated from the culture and the plasmid DNA was digested with *PmlI* to linearise the parental plasmid. The plasmid DNA, now enriched for mutated plasmid, was used to transform *E. coli* HMS174 by electroporation and transformants selected on LB plates

containing 75µgml⁻¹ ampicillin.

Colonies were grown overnight and plasmid mini-preparations performed. Constructs were screened using PmlI and those which were insensitive to digestion were further screened by KpnI PstI double digestion. Candidate clones were sequenced to verify the sequence, named pSHELFδmodified.

Sequencing confirmed the region immediately surrounding the deletion was correct. PstI and BssHII restriction sites surrounding the correct region of pSHELFδmodified were used to remove the desired segment and re-insert it into the corresponding site of pSHELF. 6.5µg pSHELF and 7.5µg pSHELFδmodified were digested with BssHII, precipitated and digested with PstI. The appropriate three fragments were gel-purified and ligated. DNA was transformed into E. coli XL1-Blue and transformants selected on plates containing 75µgml ampicillin.

Plasmids were isolated by mini-preparations and screened using BglI digestion. A candidate clone was further analysed by restriction enzyme digestion and sequenced, and named pSHELFδ26A.

Example 2: Synthesis of Exon 26A

The region of SHEL corresponding to exon 26A was amplified by PCR, with primers modified to introduce an in-frame BamH1 site upstream and a stop codon downstream at the 3' end. Two forms were generated: one terminating in valine (26AV) and the other terminating in phenyalanine (26AF). These forms are as follows:
GADEGVRRSLSPELREGDPSSSQHLPSTPSSPRV with properties:

Molecular weight = 3588.80
Residues = 34
Average Residue Weight = 105.553
Charge = -1
Isoelectric point = 5.71

and

GADEGVRRSLSPELREGDPSSSQHLPSTPSPRF

A 26A coding region was expressed as a glutathione S-transferase (GST) fusion protein.

Example 3: Glycosaminoglycan binding activity of Exon 26A

Ultrafiltration assay methodology was developed to examine and quantify interactions occurring in vitro between the 26A region and purified extracellular matrix glycosaminoglycans. GST26A fusion protein and tropoelastin were compared with GST and tropoelastin lacking exon 26A at physiologicaly relevant conditions of pH and ionic strength.

Experimental evidence supports the notion that peptide 26A (26AF and 26AV) binds GAGs. Immobilised heparin column binding shows that GST26A binds more tightly than does GST, and requires a higher sodium chloride concentration for elution (Figure 6B). Furthermore, GST26A fusion protein binds radioactive heparin with greater efficiencies than GST, and these can be compared with GAGs including chondroitin sulphates and keratin sulphates. An implication of this is that GAGs binding to tropoelastin can be adjusted based upon the content of 26A. Cross-linked tropoelastin would be expected to show differential binding to GAGs based on the relative amounts of SHEL vs. SHELδ26A.

In summary, these studies reveal that the 26A region is a functional glycosaminoglycan binding domain, which functions in intact tropoelastin. It is also active when isolated as a fusion entity yet displays no detectable structure in the absence of bound GAG. Furthermore, panel competition studies indicate a preference for those GAGs found in close association with the elastic fibre in the extracellular matrix.

Example 4: Construction of pSHELgamma, pSHEL31-34, pSHEL32-36 and pSHELgammaδ16A

pSHELgamma is derived from the pSHELgamma construct disclosed in WO94 14954. pSHEL31-34 pSHEL32-36 and pSHELgammaδ16A were derived from pSHELgamma. pSHELgamma was modified by introducing an oligonucleotide linker at the XpnI site. This encoded a factor Xa cleavage site which could be utilised in subsequent constructs. PCR and site directed mutagenesis was then used to generate further, shorter forms which provided fusions with GST. Constructs were DNA sequenced for verification. Induced protein was isolated as GST-fusion proteins, which were subsequently bound to glutathione agarose. Protease cleavage was optional where fusion proteins were desired otherwise the cleaved proteins and peptides were further purified by reverse phase HPLC.

INDUSTRIAL APPLICATION

The derivatives and expression products of the invention are of use in inter alia the medical pharmaceutical, veterinary and cosmetic fields.

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SEQUENCE LISTING

(1) GENERAL INFORMATION:

(i) APPLICANT: WEISS, ANTHONY S
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(ii) TITLE OF INVENTION: TROPOELASTIN DERIVATIVES

(iii) NUMBER OF SEQUENCES: 15

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(D) STATE: NEW SOUTH WALES
(E) COUNTRY: AUSTRALIA
(F) ZIP: 2060

(v) COMPUTER READABLE FORM:
(A) MEDIUM TYPE: Floppy disk
(B) COMPUTER: IBM PC compatible
(C) OPERATING SYSTEM: PC-DOS/MS-DOS
(D) SOFTWARE: PatentIn Release #1.0, Version #1.30

(vi) CURRENT APPLICATION DATA:
(A) APPLICATION NUMBER: AU
(B) FILING DATE:
(C) CLASSIFICATION:

(vii) PRIOR APPLICATION DATA:
(A) APPLICATION NUMBER: AU PO8117
(B) FILING DATE: 18-JUL-1997

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(C) REFERENCE/DOCKET NUMBER: 04828ZK

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(C) TELEX: 26547

(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 2210 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: double
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: YES

(iv) ANTI-SENSE: NO

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

GATCCATGGG TGGCGTTCCG GGTGCTATCC CGGGTGGCGT TCCGGGTGGT GTATTCTACC 60

CAGGCGCGGG TCTGGGTGCA CTGGGCGGTG GTGCGCTGGG CCCGGGTGGT AAACCGCTGA 120

AACCGGTTCC AGGCGGTCTG GCAGGTGCTG GTCTGGGTGC AGGTCTGGGC GCGTTCCCGG 180

CGGTTACCTT CCCGGGTGCT CTGGTTCCGG GTGGCGTTGC AGACGCAGCT GCTGCGTACA 240

AAGCGGCAAA GGCAGGTGCG GGTCTGGGCG GGGTACCAGG TGTTGGCGGT CTGGGTGTAT 300

CTGCTGGCGC AGTTGTTCCG CAGCCGGGTG CAGGTGTAAA ACCGGGCAAA GTTCCAGGTG 360

TTGGTCTGCC GGGCGTATAC CCGGGTGGTG TTCTGCCGGG CGCGCGTTTC CCAGGTGTTG 420

GTGTACTGCC GGGCGTTCCG ACCGGTGCAG GTGTTAAACC GAAGGCACCA GGTGTAGGCG 480

GCGCGTTCGC GGGTATCCCG GGTGTTGGCC CGTTCGGTGG TCCGCAGCCA GGCGTTCCGC 540

TGGGTTACCC GATCAAAGCG CCGAAGCTTC CAGGTGGCTA CGGTCTGCCG TACACCACCG 600

GTAAACTGCC GTACGGCTAC GGTCCGGGTG GCGTAGCAGG TGCTGCGGGT AAAGCAGGCT 660

ACCCAACCGG TACTGGTGTT GGTCCGCAGG CTGCTGCGGC AGCTGCGGCG AAGGCAGCAG 720

CAAAATTCGG CGCGGGTGCA GCGGGTGTTC TGCCGGGCGT AGGTGGTGCT GGCGTTCCGG 780

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CTGCGGCTGC GGCAGCTTCG GCGAAAGCAG CTAAATACGG TGCGGCAGCA GGCCTGGTTC 900

CGGGTGGTCC AGGCTTCGGT CCGGGTGTTG TAGGCGTTCC GGGTGCTGGT GTTCCGGGCG 960

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TTCCAGGTGT TGTATCCCCG GAAGCGGCAG CTAAGGCTGC TGCGAAAGCT GCGAAATACG 1080

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TCCCAGGTTT CGGCGTTGGT GTTGGTGGCA TCCCGGGTGT AGCTGGTGTT CCGTCTGTTG 1200

GTGGCGTACC GGGTGTTGGT GGCGTTCCAG GTGTAGGTAT CTCCCCGGAA GCGCAGGCAG 1260

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CACCAGGTGT AGGTGTTGCG CCGGGCGTTG GTGTAGCACC GGGTATCGGT CCGGGTGGCG 1500

TTGCGGCTGC TGCGAAATCT GCTGCGAAGG TTGCTGCGAA AGCGCAGCTG CGTGCAGCAG 1560

CTGGTCTGGG TGCGGGCATC CCAGGTCTGG GTGTAGGTGT TGGTGTTCCG GGCCTGGGTG 1620

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CGGACGAAGG TGTACGTCGT TCCCTGTCTC CAGAACTGCG TGAAGGTGAC CCGTCCTCTT 1740

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AGTTCCCACT GGGCGGTGTA GCGGCACGTC CGGGTTTCGG TCTGTCCCCG ATCTTCCCAG 2160

GCGGTGCATG CCTGGGTAAA GCTTGCGGCC GTAAACGTAA ATAATGATAG 2210

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 733 amino acids
(B) TYPE: amino acid
(C) STRANDEDNESS:
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

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Ser Met Gly Gly Val Pro Gly Ala Ile Pro Gly Gly Val Pro Gly Gly
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            20                  25                  30

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        35                  40                  45

Ala Gly Leu Gly Ala Gly Leu Gly Ala Phe Pro Ala Val Thr Phe Pro
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Gly Ala Leu Val Pro Gly Gly Val Ala Asp Ala Ala Ala Ala Tyr Lys
65                  70                  75                  80

Ala Ala Lys Ala Gly Ala Gly Leu Gly Gly Val Pro Gly Val Gly Gly
                85                  90                  95

Leu Gly Val Ser Ala Gly Ala Val Val Pro Gln Pro Gly Ala Gly Val
            100                 105                 110

Lys Pro Gly Lys Val Pro Gly Val Gly Leu Pro Gly Val Tyr Pro Gly
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Gly Val Leu Pro Gly Ala Arg Phe Pro Gly Val Gly Val Leu Pro Gly
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Val Pro Thr Gly Ala Gly Val Lys Pro Lys Ala Pro Gly Val Gly Gly
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Ala Phe Ala Gly Ile Pro Gly Val Gly Pro Phe Gly Gly Pro Gln Pro
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165 170 175

Gly Val Pro Leu Gly Tyr Pro Ile Lys Ala Pro Lys Leu Pro Gly Gly
180 185 190

Tyr Gly Leu Pro Tyr Thr Thr Gly Lys Leu Pro Tyr Gly Tyr Gly Pro
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Gly Gly Val Ala Gly Ala Ala Gly Lys Ala Gly Tyr Pro Thr Gly Thr
210 215 220

Gly Val Gly Pro Gln Ala Ala Ala Ala Ala Ala Ala Lys Ala Ala Ala
225 230 235 240

Lys Phe Gly Ala Gly Ala Ala Gly Val Leu Pro Gly Val Gly Gly Ala
245 250 255

Gly Val Pro Gly Val Pro Gly Ala Ile Pro Gly Ile Gly Gly Ile Ala
260 265 270

Gly Val Gly Thr Pro Ala Ala Ala Ala Ala Ala Ala Ala Ala Ala Lys
275 280 285

Ala Ala Lys Tyr Gly Ala Ala Ala Gly Leu Val Pro Gly Gly Pro Gly
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Phe Gly Pro Gly Val Val Gly Val Pro Gly Ala Gly Val Pro Gly Val
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Gly Val Pro Gly Ala Gly Ile Pro Val Val Pro Gly Ala Gly Ile Pro
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340 345 350

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Gly Ile Pro Thr Tyr Gly Val Gly Ala Gly Gly Phe Pro Gly Phe Gly
370 375 380

Val Gly Val Gly Gly Ile Pro Gly Val Ala Gly Val Pro Ser Val Gly
385 390 395 400

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Pro Ala Ala Ala Ala Ala Lys Ala Ala Ala Lys Ala Ala Gln Phe Gly
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450 455 460

Val Gly Val Ala Pro Gly Val Gly Leu Ala Pro Gly Val Gly Val Ala
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Pro Gly Val Gly Val Ala Pro Gly Val Gly Val Ala Pro Gly Ile Gly
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Pro Gly Gly Val Ala Ala Ala Ala Lys Ser Ala Ala Lys Val Ala Ala
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Lys Ala Gln Leu Arg Ala Ala Ala Gly Leu Gly Ala Gly Ile Pro Gly
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Leu Gly Val Gly Val Gly Val Pro Gly Leu Gly Val Gly Ala Gly Val
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Pro Gly Leu G Val Gly Ala Gly Val Pro Gly Phe Gly Ala Gly Ala
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Pro Gly Val Leu Gly Gly Leu Gly Ala Leu Gly Gly Val Gly Ile Pro
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Gly Gly Val Val Gly Ala Gly Pro Ala Ala Ala Ala Ala Ala Ala Lys
625 630 635 640

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675 680 685

Ala Gly Leu Gly Gly Val Leu Gly Gly Ala Gly Gln Phe Pro Leu Gly
690 695 700

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(2) INFORMATION FOR SEQ ID NO:3:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 698 amino acids
(B) TYPE: amino acid
(C) STRANDEDNESS:
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

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Gly Lys Val Pro Gly Val Gly Leu Pro Gly Val Tyr Pro Gly Gly Val
115 120 125

Leu Pro Gly Ala Arg Phe Pro Gly Val Gly Val Leu Pro Gly Val Pro
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Thr Gly Ala Gly Val Lys Pro Lys Ala Pro Gly Val Gly Gly Ala Phe
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Ala Gly Ile Pro Gly Val Gly Pro Phe Gly Gly Pro Gln Pro Gly Val
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Pro Leu Gly Tyr Pro Ile Lys Ala Pro Lys Leu Pro Gly Gly Tyr Gly
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195 200 205

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Gly Pro Gln Ala Ala Ala Ala Ala Ala Ala Lys Ala Ala Ala Lys Phe
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305 310 315 320

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325 330 335

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340 345 350

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515 520 525

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Leu Ala Ala Ala Lys Ala Ala Lys Tyr Gly Ala Ala Val Pro Gly Val
565 570 575

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580 585 590

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595 600 605

Lys Ala Ala Gln Phe Gly Leu Val Gly Ala Ala Gly Leu Gly Gly Leu
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645 650 655

Gly Gly Val Leu Gly Gly Ala Gly Gln Phe Pro Leu Gly Gly Val Ala
660 665 670

Ala Arg Pro Gly Phe Gly Leu Ser Pro Ile Phe Pro Gly Gly Ala Cys
675 680 685

Leu Gly Lys Ala Cys Gly Arg Lys Arg Lys
690 695

(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 1983 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: double
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: YES

(iv) ANTI-SENSE: NO

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

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GCAGTTGTTC CGCAGCCGGG TGCAGGTGTA AAACCGGGCA AAGTTCCAGG TGTTGGTCTG 240

CCGGGCGTAT ACCCGGGTTT CGGTGCTGTT CCGGGCGCGC GTTTCCCAGG TGTTGGTGTA 300

CTGCCGGGCG TTCCGACCGG TGCAGGTGTT AAACCGAAGG CACCAGGTGT AGGCGGCGCG 360

TTCGCGGGTA TCCCGGGTGT TGGCCCGTTC GGTGGTCCGC AGCCAGGCGT TCCGCTGGGT 420

TACCCGATCA AAGCGCCGAA GCTTCCAGGT GGCTACGGTC TGCCGTACAC CACCGGTAAA 480

CTGCCGTACG GCTACGGTCC GGGTGGCGTA GCAGGTGCTG CGGGTAAAGC AGGCTACCCA 540

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GTTGGTGGCG TACCGGGTGT TGGTGGCGTT CCAGGTGTAG GTATCTCCCC GGAAGCGCAG 1140

GCAGCTGCGG CAGCTAAAGC AGCGAAGTAC GGCGTTGGTA CTCCGGCGGC AGCAGCTGCT 1200

AAAGCAGCGG CTAAAGCAGC GCAGTTCGGA CTAGTTCCGG GCGTAGGTGT TGCGCCAGGT 1260

GTTGGCGTAG CACCGGGTGT TGGTGTTGCT CCGGGCGTAG GTCTGGCACC GGGTGTTGGC 1320

GTTGCACCAG GTGTAGGTGT TGCGCCGGGC GTTGGTGTAG CACCGGGTAT CGGTCCGGGT 1380

GGCGTTGCGG CTGCTGCGAA ATCTGCTGCG AAGGTTGCTG CGAAAGCGCA GCTGCGTGCA 1440

GCAGCTGGTC TGGGTGCGGG CATCCCAGGT CTGGGTGTAG GTGTTGGTGT TCCGGGCCTG 1500

GGTGTAGGTG CAGGGGTACC GGGCCTGGGT GTTGGTGCAG GCGTTCCGGG TTTCGGTGCT 1560

GTTCCGGGCG CGCTGGCTGC TGCGAAAGCG GCGAAATACG GTGCTGTTCC GGGTGTACTG 1620

GGCGGTCTGG GTGCTCTGGG CGGTGTTGGT ATCCCGGGCG GTGTTGTAGG TGCAGGTCCA 1680

GCTGCAGCTG CTGCTGCGGC AAAGGCAGCG GCGAAAGCAG CTCAGTTCGG TCTGGTTGGT 1740

GCAGCAGGTC TGGGCGGTCT GGGTGTTGGC GGTCTGGGTG TACCGGGCGT TGGTGGTCTG 1800

GGTGGCATCC CGCCGGCGGC GGCAGCTAAA GCGGCTAAAT ACGGTGCAGC AGGTCTGGGT 1860

GGCGTTCTGG GTGGTGCTGG TCAGTTCCCA CTGGGCGGTG TAGCGGCACG TCCGGGTTTC 1920

GGTCTGTCCC CGATCTTCCC AGGCGGTGCA TGCCTGGGTA AAGCTTGCGG CCGTAAACGT 1980

AAA 1983

(2) INFORMATION FOR SEQ ID NO:5:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 660 amino acids
(B) TYPE: amino acid
(C) STRANDEDNESS:
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

Met Gly Gly Val Pro Gly Ala Val Pro Gly Gly Val Pro Gly Gly Val
1 5 10 15

Phe Tyr Pro Gly Ala Gly Phe Gly Ala Val Pro Gly Gly Val Ala Asp
20 25 30

Ala Ala Ala Ala Tyr Lys Ala Ala Lys Ala Gly Ala Gly Leu Gly Gly
35 40 45

Val Pro Gly Val Gly Gly Leu Gly Val Ser Ala Gly Ala Val Val Pro
50 55 60

Gln Pro Gly Ala Gly Val Lys Pro Gly Lys Val Pro Gly Val Gly Leu
65 70 75 80

Pro Gly Val Tyr Pro Gly Phe Gly Ala Val Pro Gly Ala Arg Phe Pro
85 90 95

Gly Val Gly Val Leu Pro Gly Val Pro Thr Gly Ala Gly Val Lys Pro
100 105 110

Lys Ala Pro Gly Val Gly Gly Ala Phe Ala Gly Ile Pro Gly Val Gly
115 120 125

Pro Phe Gly Gly Pro Gln Pro Gly Val Pro Leu Gly Tyr Pro Ile Lys
130 135 140

Ala Pro Lys Leu Pro Gly Gly Tyr Gly Leu Pro Tyr Thr Thr Gly Lys
145 150 155 160

Leu Pro Tyr Gly Tyr Gly Pro Gly Gly Val Ala Ala Ala Gly Lys Ala
165 170 175

Gly Tyr Pro Thr Gly Thr Gly Val Gly Pro Gln Ala Ala Ala Ala Ala
180 185 190

Ala Ala Lys Ala Ala Ala Lys Phe Gly Ala Gly Ala Ala Gly Phe Gly
195 200 205

Ala Val Pro Gly Val Gly Gly Ala Gly Val Pro Gly Val Pro Gly Ala
210 215 220

Ile Pro Gly Ile Gly Gly Ile Ala Gly Val Gly Thr Pro Ala Ala Ala
225 230 235 240

Ala Ala Ala Ala Ala Ala Ala Lys Ala Ala Lys Tyr Gly Ala Ala Ala
245 250 255

Gly Leu Val Pro Gly Gly Pro Gly Phe Gly Pro Gly Val Val Gly Val
260 265 270

Pro Gly Phe Gly Ala Val Pro Gly Val Gly Val Pro Gly Ala Gly Ile
275 280 285

Pro Val Val Pro Gly Ala Gly Ile Pro Gly Ala Ala Gly Phe Gly Ala
290 295 300

Val Ser Pro Gly Ala Ala Ala Lys Ala Ala Ala Lys Ala Ala Lys Tyr

305 310 315 320

Gly Ala Arg Pro Gly Val Gly Val Gly Gly Ile Pro Thr Tyr Gly Val
325 330 335

Gly Ala Gly Phe Phe Pro Gly Phe Gly Val Gly Val Gly Gly Ile Pro
340 345 350

Gly Val Ala Gly Val Pro Ser Val Gly Gly Val Pro Gly Val Gly Gly
355 360 365

Val Pro Gly Val Gly Ile Ser Pro Glu Ala Gln Ala Ala Ala Ala Ala
370 375 380

Lys Ala Ala Lys Tyr Gly Val Gly Thr Pro Ala Ala Ala Ala Ala Lys
385 390 395 400

Ala Ala Ala Lys Ala Ala Gln Phe Gly Leu Val Pro Gly Val Gly Val
405 410 415

Ala Pro Gly Val Gly Val Ala Pro Gly Val Gly Val Ala Pro Gly Val
420 425 430

Gly Leu Ala Pro Gly Val Gly Val Ala Pro Gly Val Gly Val Ala Pro
435 440 445

Gly Val Gly Val Ala Pro Gly Ile Gly Pro Gly Gly Val Ala Ala Ala
450 455 460

Ala Lys Ser Ala Ala Lys Val Ala Ala Lys Ala Gln Leu Arg Ala Ala
465 470 475 480

Ala Gly Leu Gly Ala Gly Ile Pro Gly Leu Gly Val Gly Val Gly Val
485 490 495

Pro Gly Leu Gly Val Gly Ala Gly Val Pro Gly Leu Gly Val Gly Ala
500 505 510

Gly Val Pro Gly Phe Gly Ala Val Pro Gly Ala Leu Ala Ala Ala Lys
515 520 525

Ala Ala Lys Tyr Gly Ala Val Pro Gly Val Leu Gly Gly Leu Gly Ala
530 535 540

Leu Gly Gly Val Gly Ile Pro Gly Gly Val Val Gly Ala Gly Pro Ala
545 550 555 560

Ala Ala Ala Ala Ala Ala Lys Ala Ala Ala Lys Ala Ala Gln Phe Gly
565 570 575

Leu Val Gly Ala Ala Gly Leu Gly Gly Leu Gly Val Gly Gly Leu Gly
580 585 590

Val Pro Gly Val Gly Gly Leu Gly Gly Ile Pro Pro Ala Ala Ala Ala
595 600 605

Lys Ala Ala Lys Tyr Gly Ala Ala Gly Leu Gly Gly Val Leu Gly Gly
610 615 620

Ala Gly Gln Phe Pro Leu Gly Gly Val Ala Ala Arg Pro Gly Phe Gly
625 630 635 640

Leu Ser Pro Ile Phe Pro Gly Gly Ala Cys Leu Gly Lys Ala Cys Gly
645 650 655

Arg Lys Arg Lys
660

(2) INFORMATION FOR SEQ ID NO:6:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 441 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: double
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: YES

(iv) ANTI-SENSE: NO

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

TCCGCCATGG GAGGTGTTCC GGGCGCGCTG GCTGCTGCGA AAGCGGCGAA ATACGGTGCA 60

GCGGTTCCGG GTGTACTGGG CGGTCTGGGT GCTCTGGGCG GTGTTGGTAT CCCGGGCGGT 120

GTTGTAGGTG CAGGCCCAGC TGCAGCTGCT GCTGCGGCAA AGGCAGCGGC GAAAGCAGCT 180

CAGTTCGGTC TGGTTGGTGC AGCAGGTGTG GGCGGTCTGG GTGTTGGCGG TCTGGGTGTA 240

CCGGGCGTTG GTGGTCTGGG TGGCATCCCG CCGGCGGCGG CAGCTAAAGC GGCTAAATAC 300

GGTGCAGCAG GTCTGGGTGG CGTTCTGGGT GGTGCTGGTC AGTTCCCACT GGGCGGTGTA 360

GCGGCACGTC CGGGTTTCGG TCTGTCCCCG ATCTTCCCAG GCGGTGCATG CCTGGGTAAA 420

GCTTGCGGCC GTAAACGTAA A 441

(2) INFORMATION FOR SEQ ID NO:7:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 147 amino acids
(B) TYPE: amino acid
(C) STRANDEDNESS:
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

Ser Ala Met Gly Gly Val Pro Gly Ala Leu Ala Ala Ala Lys Ala Ala
1 5 10 15

Lys Tyr Gly Ala Ala Val Pro Gly Val Leu Gly Gly Leu Gly Ala Leu
20 25 30

Gly Gly Val Gly Ile Pro Gly Gly Val Val Gly Ala Gly Pro Ala Ala
35 40 45

Ala Ala Ala Ala Ala Lys Ala Ala Ala Lys Ala Ala Gln Phe Gly Leu
50 55 60

Val Gly Ala Ala Gly Leu Gly Gly Leu Gly Val Gly Gly Leu Gly Val
65 70 75 80

Pro Gly Val Gly Gly Leu Gly Gly Ile Pro Pro Ala Ala Ala Ala Lys
85 90 95

Ala Ala Lys Tyr Gly Ala Ala Gly Leu Gly Gly Val Leu Gly Gly Ala
100 105 110

Gly Gln Phe Pro Leu Gly Gly Val Ala Ala Arg Pro Gly Phe Gly Leu
115 120 125

Ser Pro Ile Phe Pro Gly Gly Ala Cys Leu Gly Lys Ala Cys Gly Arg
130 135 140

Lys Arg Lys
145

(2) INFORMATION FOR SEQ ID NO:8:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 600 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: double
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(iii) HYPOTHETICAL: YES

(iv) ANTI-SENSE: NO

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

TCCGCCATGG GAGCTCTGGT AGGCCTGGGC GTACCGGGCC TGGGTGTTGG TGCAGGCGTT 60

CCGGGTTTCG GTGCTGGCGC GGACGAAGGT GTACGTCGTT CCCTGTCTCC AGAACTGCGT 120

GAAGGTGACC CGTCCTCTTC CCAGCACCTG CCGTCTACCC CGTCCTCTCC ACGTGTTCCG 180

GGCGCGCTGG CTGCTGCGAA AGCGGCGAAA TACGGTGCAG CGGTTCCGGG TGTACTGGGC 240

GGTCTGGGTG CTCTGGGCGG TGTTGGTATC CCGGGCGGTG TTGTAGGTGC AGGCCCAGCT 300

GCAGCTGCTG CTGCGGCAAA GGCAGCGGCG AAAGCAGCTC AGTTCGGTCT GGTTGGTGCA 360

GCAGGTCTGG GCGGTCTGGG TGTTGGCGGT CTGGGTGTAC CGGGCGTTGG TGGTCTGGGT 420

GGCATCCCGC CGGCGGCGGC AGCTAAAGCG GCTAAATACG GTGCAGCAGG TCTGGGTGGC 480

GTTCTGGGTG GTGCTGGTCA GTTCCCACTG GGCGGTGTAG CGGCACGTCC GGGTTTCGGT 540

CTGTCCCCGA TCTTCCCAGG CGGTGCATGC CTGGGTAAAG CTTGCGGCCG TAAACGTAAA 600

(2) INFORMATION FOR SEQ ID NO:9:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 200 amino acids
(B) TYPE: amino acid
(C) STRANDEDNESS:
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

Ser Ala Met Gly Ala Leu Val Gly Leu Gly Val Pro Gly Leu Gly Val
1 5 10 15

Gly Ala Gly Val Pro Gly Phe Gly Ala Gly Ala Asp Glu Gly Val Arg
20 25 30

Arg Ser Leu Ser Pro Glu Leu Arg Glu Gly Asp Pro Ser Ser Ser Gln
35 40 45

His Leu Pro Ser Thr Pro Ser Ser Pro Arg Val Pro Gly Ala Leu Ala
50 55 60

Ala Ala Lys Ala Ala Lys Tyr Gly Ala Ala Val Pro Gly Val Leu Gly
65 70 75 80

Gly Leu Gly Ala Leu Gly Gly Val Gly Ile Pro Gly Gly Val Val Gly
85 90 95

Ala Gly Pro Ala Ala Ala Ala Ala Ala Ala Lys Ala Ala Ala Lys Ala
100 105 110

Ala Gln Phe Gly Leu Val Gly Ala Ala Gly Leu Gly Gly Leu Gly Val
115 120 125

Gly Gly Leu Gly Val Pro Gly Val Gly Gly Leu Gly Gly Ile Pro Pro
130 135 140

Ala Ala Ala Ala Lys Ala Ala Lys Tyr Gly Ala Ala Gly Leu Gly Gly
145 150 155 160

Val Leu Gly Gly Ala Gly Gln Phe Pro Leu Gly Gly Val Ala Ala Arg
165 170 175

Pro Gly Phe Gly Leu Ser Pro Ile Phe Pro Gly Gly Ala Cys Leu Gly
180 185 190

Lys Ala Cys Gly Arg Lys Arg Lys
195 200

(2) INFORMATION FOR SEQ ID NO:10:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 60 amino acids
(B) TYPE: amino acid
(C) STRANDEDNESS:
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

Gly Ile Pro Pro Ala Ala Ala Ala Lys Ala Ala Lys Tyr Gly Ala Ala
1 5 10 15

Gly Leu Gly Gly Val Leu Gly Gly Ala Gly Gln Phe Pro Leu Gly Gly
20 25 30

Val Ala Ala Arg Pro Gly Phe Gly Leu Ser Pro Ile Phe Pro Gly Gly
35 40 45

Ala Cys Leu Gly Lys Ala Cys Gly Arg Lys Arg Lys
50 55 60

(2) INFORMATION FOR SEQ ID NO:11:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 47 amino acids
(B) TYPE: amino acid
(C) STRANDEDNESS:
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

Gly Ala Ala Gly Leu Gly Gly Val Leu Gly Gly Ala Gly Gln Phe Pro
1 5 10 15

Leu Gly Gly Val Ala Ala Arg Pro Gly Phe Gly Leu Ser Pro Ile Phe
20 25 30

Pro Gly Gly Ala Cys Leu Gly Lys Ala Cys Gly Arg Lys Arg Lys
35 40 45

(2) INFORMATION FOR SEQ ID NO:12:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 34 amino acids
(B) TYPE: amino acid
(C) STRANDEDNESS:
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

Gly Ala Asp Glu Gly Val Arg Arg Ser Leu Ser Pro Glu Leu Arg Glu
1 5 10 15

Gly Asp Pro Ser Ser Ser Gln His Leu Pro Ser Thr Pro Ser Ser Pro
20 25 30

Arg Val

(2) INFORMATION FOR SEQ ID NO:13:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 34 amino acids
(B) TYPE: amino acid

(C) STRANDEDNESS:
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:

Gly Ala Asp Glu Gly Val Arg Arg Ser Leu Ser Pro Glu Leu Arg Glu
1 5 10 15

Gly Asp Pr Ser Ser Ser Gln His Leu Pro Ser Thr Pro Ser Ser Pro
20 25 30

Arg Phe

(2) INFORMATION FOR SEQ ID NO:14:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 216 amino acids
(B) TYPE: amino acid
(C) STRANDEDNESS:
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:

Ala Ala Ala Gly Leu Gly Ala Gly Ile Pro Gly Leu Gly Val Gly Val
1 5 10 15

Gly Val Pro Gly Leu Gly Val Gly Ala Gly Val Pro Gly Leu Gly Val
20 25 30

Gly Ala Gly Val Pro Gly Phe Gly Ala Gly Ala Asp Glu Gly Val Arg
35 40 45

Arg Ser Leu Ser Pro Glu Leu Arg Glu Gly Asp Pro Ser Ser Ser Gln
50 55 60

His Leu Pro Ser Thr Pro Ser Ser Pro Arg Val Pro Gly Ala Leu Ala
65 70 75 80

Ala Ala Lys Ala Ala Lys Tyr Gly Ala Ala Val Pro Gly Val Leu Gly
85 90 95

Gly Leu Gly Ala Leu Gly Gly Val Gly Ile Pro Gly Gly Val Val Gly
100 105 110

Ala Gly Pro Ala Ala Ala Ala Ala Ala Ala Lys Ala Ala Ala Lys Ala
115 120 125

Ala Gln Phe Gly Leu Val Gly Ala Ala Gly Leu Gly Gly Leu Gly Val
130 135 140

Gly Gly Leu Gly Val Pro Gly Val Gly Gly Leu Gly Gly Ile Pro Pro
145 150 155 160

Ala Ala Ala Ala Lys Ala Ala Lys Tyr Gly Ala Ala Gly Leu Gly Gly
165 170 175

Val Leu Gly Gly Ala Gly Gln Phe Pro Leu Gly Gly Val Ala Ala Arg
180 185 190

Pro Gly Phe Gly Leu Ser Pro Ile Phe Pro Gly Gly Ala Cys Leu Gly
195 200 205

Lys Ala Cys Gly Arg Lys Arg Lys
210 215

(2) INFORMATION FOR SEQ ID NO:15:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 183 amino acids
(B) TYPE: amino acid
(C) STRANDEDNESS:
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:

Ala [illegible] Gly Leu [illegible] Gly Ile Pro [illegible]

1 5 10 15

Gly Val Pro Gly Leu Gly Val Gly Ala Gly Val Pro Gly Leu Gly Val
20 25 30

Gly Ala Gly Val Pro Gly Phe Gly Ala Val Pro Gly Ala Leu Ala Ala
35 40 45

Ala Lys Ala Ala Lys Tyr Gly Ala Ala Val Pro Gly Val Leu Gly Gly
50 55 60

Leu Gly Ala Leu Gly Gly Val Gly Ile Pro Gly Gly Val Val Gly Ala
65 70 75 80

Gly Pro Ala Ala Ala Ala Ala Ala Ala Lys Ala Ala Ala Lys Ala Ala
85 90 95

Gln Phe Gly Leu Val Gly Ala Ala Gly Leu Gly Gly Leu Gly Val Gly
100 105 110

Gly Leu Gly Val Pro Gly Val Gly Gly Leu Gly Gly Ile Pro Pro Ala
115 120 125

Ala Ala Ala Lys Ala Ala Lys Tyr Gly Ala Ala Gly Leu Gly Gly Val
130 135 140

Leu Gly Gly Ala Gly Gln Phe Pro Leu Gly Gly Val Ala Ala Arg Pro
145 150 155 160

Gly Phe Gly Leu Ser Pro Ile Phe Pro Gly Gly Ala Cys Leu Gly Lys
165 170 175

Ala Cys Gly Arg Lys Arg Lys
180

THE CLAIMS:

1. A human tropoelastin derivative or an amino acid sequence variant thereof, wherein the derivative or variant has elastin-like properties.

2. A human tropoelastin derivative or an amino acid sequence variant thereof, wherein the derivative or variant has macro-molecular binding properties.

3. A derivative or variant thereof according to claim 2 wherein the macro-molecular binding properties include the ability to bind glycosyaminoglycans.

4. A human tropoelastin derivative or an amino acid sequence variant thereof, wherein the derivative or variant has elastin-like properties and macro-molecular binding properties.

5. A polynucleotide encoding a derivative or variant thereof of any one of claims 1 to 4.

6. A tropoelastin derivative comprising the amino acid sequence of SHELδmodified, or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELδmodified.

7. A tropoelastin derivative according to claim 6 comprising SEQ ID NO: 5.

8. A polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of SHELδmodified or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELδmodified.

9. A polynucleotide according to claim 8 comprising SEQ ID NO: 4.

10. A synthetic polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of SHELδ26A or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELδ26A.

11. A synthetic polynucleotide according to claim 10, the polynucleotide comprising the sequence of from nucleotide position 1 to 1676 contiguous with the sequence of from nucleotide position 1775 to 2210 of SEQ ID NO: 1.

12. An amino acid sequence variant of the derivative comprising the amino acid sequence of SHELδ26A.

13. An amino acid sequence variant according to claim 12 comprising SEQ ID NO:3.

14. A tropoelastin derivative comprising the amino acid sequence of SHELgamma, or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELgamma.

15. A tropoelastin derivative according to claim 14 comprising SEQ ID NO:9.

16. A polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of the derivative SHELgamma, or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELgamma.

17. A polynucleotide sequence according to claim 16 comprising SEQ ID NO:8.

18. A tropoelastin derivative comprising the amino acid sequence of SHELgamma excluding exon 26A, or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELgamma excluding exon 26A.

19. A tropoelastin derivative according to claim 18 comprising SEQ ID NO:7.

20. A polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of SHELgamma excluding exon 26A or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHELgamma excluding exon 26A.

21. A polynucleotide sequence according to claim 20 comprising SEQ ID NO: 6.

22. A tropoelastin derivative comprising the amino acid sequence of SHEL31-36, or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHEL31-36.

23. A tropoelastin derivative according to claim 22 comprising SEQ ID NO: 10.

24. A polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of SHEL31-36 or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHEL31-36.

25. A polynucleotide according to claim 24, the polynucleotide comprising the sequence of from nucleotide position 2022 to 2210 of SEQ ID NO: 1.

26. A tropoelastin derivative comprising the amino acid sequence of SHEL32-36, or an amino acid sequence variant of the derivative comprising the amino acid

sequence of SHEL32-36.

27. A tropoelastin derivative according to claim 26 comprising SEQ ID NO: 11.

28. A polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of SHEL32-36 or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHEL32-36.

29. A polynucleotide according to claim 28, the polynucleotide comprising the sequence of from nucleotide position 2061 to 2210 of SEQ ID NO: 1.

30. A tropoelastin derivative comprising the amino acid sequence of peptide 26A, or an amino acid sequence variant of the derivative comprising the amino acid sequence of peptide 26A.

31. A tropoelastin derivative according to claim 30 comprising SEQ ID NO: 12 or SEQ ID NO: 13.

32. A polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of peptide 26A or an amino acid sequence variant of the derivative comprising the amino acid sequence of peptide 26A.

33. A polynucleotide according to claim 32, the polynucleotide comprising the sequence of from nucleotide position 1677 to 1774 of SEQ ID NO: 1.

34. A tropoelastin derivative comprising the amino acid sequence of SHEL26-36, or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHEL26-26.

35. A tropoelastin derivative according to claim 34 comprising SEQ ID NO: 14.

36. A polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of SHEL26-36 or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHEL26-36.

37. A polynucleotide according to claim 36, the polynucleotide comprising the sequence of from nucleotide position 1554 to 2210 of SEQ ID NO: 1.

38. A tropoelastin derivative comprising the amino acid sequence of SHEL26-26 excluding exon 26A, or an amino acid sequence variant of the derivative comprising the amino acid sequence of SHEL26-26 excluding exon 26A.

39. A tropoelastin derivative according to claim 38 comprising SEQ ID NO: 15.

40. A polynucleotide encoding a tropoelastin derivative, the derivative comprising the amino acid sequence of SHEL26-26 excluding exon 26A or an amino acid sequence variant of the derivative of SHEL26-26 excluding exon 26A.

41. A polynucleotide according to claim 40, the polynucleotide comprising the sequence of from nucleotide position 1554 to 1676 contiguous with the sequence of from nucleotide position 1776 to 2210 of SEQ ID NO: 1.

42. A vector comprising a polynucleotide according to any one of claims 5, 8, 9, 16, 17, 20, 21, 24, 25, 28, 29, 32, 33, 36, 37, 40 or 41, or a synthetic polynucleotide according to claim 10 or 11.

43. The vector according to claim 42 wherein the

polynucleotide or synthetic polynucleotide is operatively linked to a promoter or enhancer regulatory sequence.

44. The vector according to claim 42 or 43 wherein the polynucleotide or synthetic polynucleotide is operatively linked to a nucleotide sequence, the nucleotide sequence encoding a further amino acid sequence.

45. A cell containing a vector according to any one of claims 42 to 44.

46. A method for producing a derivative of tropoelastin or an amino acid sequence variant of the derivative, the method comprising:

(a) providing a vector according to any one of claims 42 to 44;
(b) introducing the vector into a cell;
(c) maintaining the cell in conditions suitable for expression of the vector; and
(d) isolating the tropoelastin derivative or variant.

47. A tropoelastin derivative or variant produced by the method of claim 46.

48. A transgenic non-human animal containing a vector according to any one of claims 42 to 44, or a polynucleotide according to any one of claims 5, 8, 9, 16, 17, 20, 21, 24, 25, 28, 29, 32, 33, 36, 37, 40 or 41, or a synthetic polynucleotide according to claim 10 or 11.

49. A tropoelastin derivative or variant of the derivative produced by a transgenic animal according to claim 48

50. method for producing a tropoelastin derivative

claims 1-4, 6, 7, 12-15, 18, 19, 22, 23, 26, 27, 30, 31, 34, 35, 38 or 39, the method comprising producing the tropoelastin derivative or variant by solid-phase peptide synthesis.

51. A tropoelastin derivative or variant produced by the method of claim 50.

52. A formulation comprising at least one tropoelastin derivative or variant of the derivative according to any one of 1-4, 6, 7, 12-15, 18, 19, 22, 23, 26, 27, 30, 31, 34, 35, 38, 39, 47 or 49, together with a pharmaceutically acceptable carrier or diluent.

53. An expression product comprising a tropoelastin derivative or variant of the derivative according to any one of claims 1-4, 6, 7, 12-15, 18, 19, 22, 23, 26, 27, 30, 31, 34, 35, 38, 39, 47 or 49, and a further amino acid sequence.

54. An expression product according to claim 53 wherein the tropoelastin derivative comprises the amino acid sequence of peptide 26A, or an amino acid sequence variant of the derivative comprising the amino acid sequence of peptide 26A.

55. A polynucleotide encoding an expression product according to claims 53 or 54.

56. A vector comprising the polynucleotide according to claim 55.

57. A cell containing a vector according to claim 56.

58. A method for producing an expression product according to claim 52 or 54, the method comprising:

(b) introducing the vector into a cell;

(c) maintaining the cell in conditions suitable for expression of the vector; and

(d) isolating the expression product.

59. An expression product produced by the method of claim 58.

60. An transgenic non-human animal containing a vector according to claim 56 or a polynucleotide according to claim 55.

61. An expression product produced by a transgenic animal according to claim 60.

62. A formulation comprising at least one expression product according to any of claims 53, 54, 59 or 61, together with a pharmaceutically acceptable carrier or diluent.

63. A hybrid molecule comprising a biological polymer wherein the polymer is linked to a tropoelastin derivative comprising the amino acid sequence of peptide 26A or an amino acid sequence variant of the derivative comprising peptide 26A.

64. A hybrid molecule according to claim 63 wherein the biological polymer is a protein.

65. A hybrid molecule according to claim 64 wherein in the protein is selected from the group consisting of cytokines, growth factors and antibodies.

66. A hybrid molecule according to claim 63 wherein the biological polymer is selected from the group consisting of lipids, sugars and nucleic acids.

67. A polynucleotide sequence encoding a hybrid

68. A vector comprising a polynucleotide sequence according to claim 67.

69. A cell containing a vector according to claim 68.

70. A method for producing a hybrid molecule according to claim 64, the method comprising:

(a) providing a vector according to claim 68;
(b) introducing the vector into a cell;
(c) maintaining the cell in conditions suitable for expression of the vector; and
(d) isolating the hybrid molecule.

71. A hybrid molecule produced by the method of claim 70.

72. A transgenic non-human animal containing a vector according to claim 68 or a polynucleotide according to claim 67.

73. A hybrid molecule produced by a transgenic animal according to claim 72.

74. A hybrid molecule comprising a synthetic polymer linked to peptide 26A or a variant of peptide 26A.

75. A formulation comprising at least one hybrid molecule according to any of claims 63-65, 71, 73 and 74, together with a pharmaceutically acceptable carrier or diluent.

76. A cross linked complex, the complex comprising at least one of the following:

(i) at least one derivative or variant of the derivative according to any of 1-4, 6, [illegible] 12-15,

or 49;

(ii) at least expression product according to any of claims 53, 54, 58 or 61; and

(iii) at least one hybrid molecule according to any of claims 63-65, 71, 73 or 74.

77. An implant, the implant comprising at least one of the following:

(i) at least one derivative or variant of the derivative according to any of 1-4, 6, 7, 12-15, 18, 19, 22, 23, 26, 27, 30, 31, 34, 35, 38, 39, 47 or 49;

(ii) at least expression product according to any of claims 53, 54, 58 or 61; and

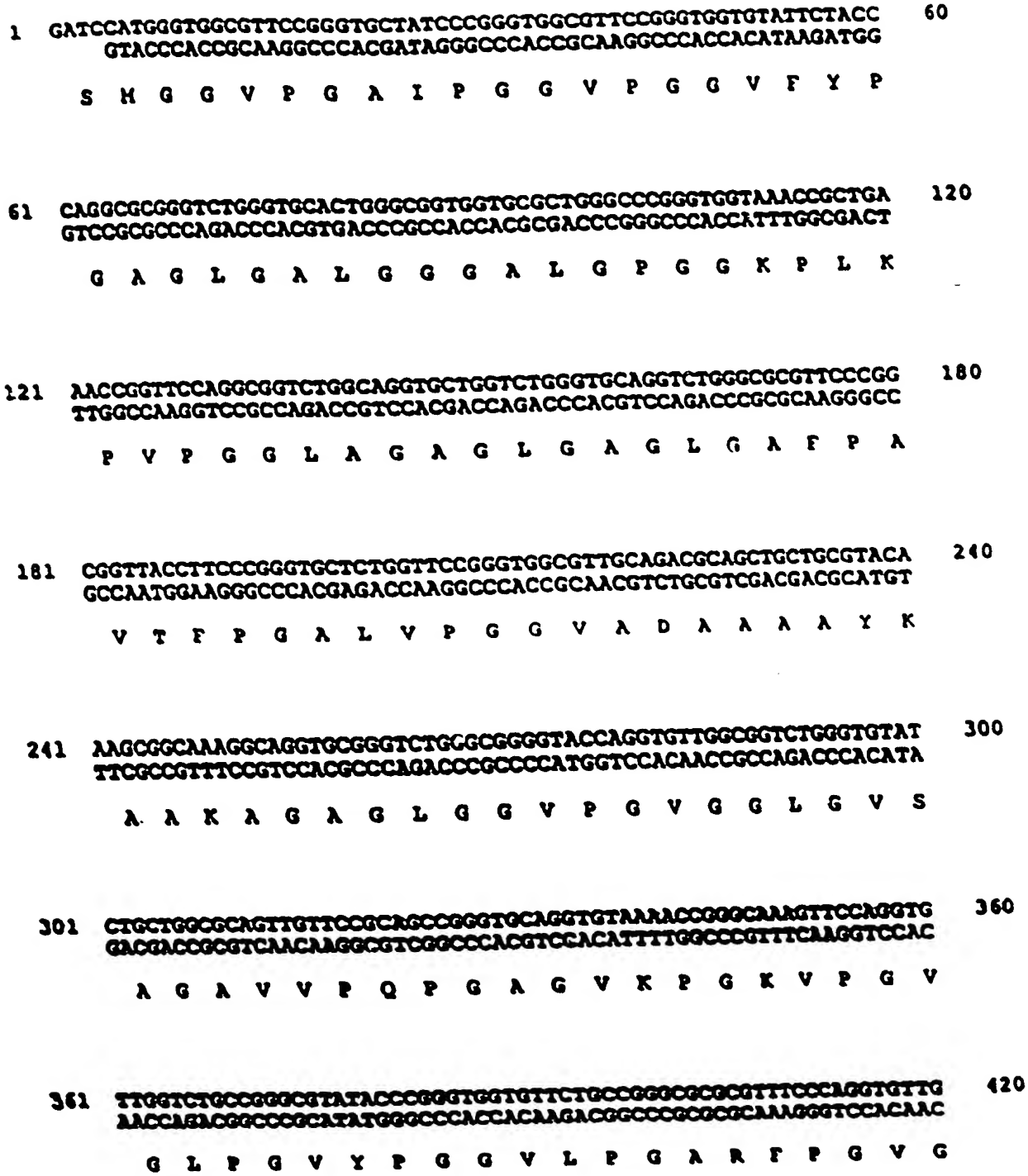
(iii) at least one hybrid molecule according to any of claims 63-65, 71, 73 or 74.

78. A method of imparting glycosaminoglycan binding activity to a biological polymer comprising the step of linking a tropoelastin derivative comprising the amino acid sequence of peptide 26A, or an amino acid sequence variant of the derivative comprising the amino acid sequence of peptide 26A with the biological polymer.

79. A method of deleting glycosaminoglycan binding activity from a biological polymer comprising the step of deleting a tropoelastin derivative comprising the amino acid sequence of peptide 26A, or an amino acid sequence variant of the derivative comprising the amino acid sequence of peptide 26A from the biological polymer.

80. The method of claim 66 or 67 wherein the biological polymer is a protein.

81. A formulation comprising a tropoelastin derivative or variant of the derivative and a synthetic or biological polymer


1 GATCCATGGGTGGCGTTCCGGGTGCTATCCCGGGTGGCGTTCCGGGTGGTGTATTCTACC 60
GTACCCACCGCAAGGCCCACGATAGGGCCCACCGCAAGGCCCACCACATAAGATGG
S H G G V P G A I P G G V P G G V F Y P
61 CAGGCGCGGGTCTGGGTGCACTGGGCGGTGGTGCGCTGGGCCCGGGTGGTAAACCGCTGA 120
GTCCGCGCCCAGACCCACGTGACCCGCCACCACGCGACCCGGGCCCACCATTTGGCGACT
G A G L G A L G G G A L G P G G K P L K
121 AACCGGTTCCAGGCGGTCTGGCAGGTGCTGGTCTGGGTGCAGGTCTGGGCGCGTTCCCGG 180
TTGGCCAAGGTCCGCCAGACCGTCCACGACCAGACCCACGTCCAGACCCGCGCAAGGGCC
P V P G G L A G A G L G A G L G A F P A
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V T F P G A L V P G G V A D A A A A Y K
241 AAGCGGCAAAGGCAGGTGCGGGTCTGGGCGGGGTACCAGGTGTTGGCGGTCTGGGTGTAT 300
TTCGCCGTTTCCGTCCACGCCCAGACCCGCCCCATGGTCCACAACCGCCAGACCCACATA
A A K A G A G L G G V P G V G G L G V S
301 CTGCTGGCGCAGTTGTTCCGCAGCCGGGTGCAGGTGTAAAACGGGCAAAGTTCCAGGTG 360
GACGACCGCGTCAACAAGGCGTCGGCCCACGTCGACATTTTGGCCCGTTTCAAGGTCCAC
A G A V V P Q P G A G V K P G K V P G V
361 TTGGTCTGCCGGGCGTATACCCGGGTGGTGTTCTGCCGGGCGCGCGTTTCCCAGGTGTTG 420
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G L P G V Y P G G V L P G A R F P G V G

Figure 1(1)

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421  GTGTACTGCCGGGCGTTCCGACCGGTGCAGGTGTTAAACCGAAGGCACCAGGTGTAGGCG   480
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       V  L  P  G  V  P  T  G  A  G  V  K  P  K  A  P  G  V  G  G

481  GCGCGTTCGCGGGTATCCCGGGTGTTGGCCCGTTCGGTGGTCCGCAGCCAGGCGTTCCGC   540
     CGCGCAAGCGCCCATAGGGCCCACAACCGGGCAAGCCACCAGGCGTCGGTCCGCAAGGCG

       A  F  A  G  I  P  G  V  G  P  F  G  G  P  Q  P  G  V  P  L

541  TGGGTTACCCGATCAAAGCGCCGAAGCTTCCAGGTGGCTACGGTCTGCCGTACACCACCG   600
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       G  Y  P  I  K  A  P  K  L  P  G  G  Y  G  L  P  Y  T  T  G

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       K  L  P  Y  G  Y  G  P  G  G  V  A  G  A  A  G  K  A  G  Y

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721  CAAAATTCGGCGCGGGTGCAGCGGGTGTTCTGCCGGGCGTAGGTGGTGCTGGCGTTCCGG   780
     GTTTTAAGCCGCGCCCACGTCGCCCACAAGACGGCCCGCATCCACCACGACCGCAAGGCC

       K  F  G  A  G  A  A  G  V  L  P  G  V  G  G  A  G  V  P  G

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     CACAAGGTCCACGGTAGGGCCCGTAGCCACCATAGCGTCCGCATCCATGAGGCCGCCGGC

       V  P  G  A  I  P  G  I  G  G  I  A  G  V  G  T  P  A  A  A

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       G  G  P  G  F  G  P  G  V  V  G  V  P  G  A  G  V  P  G  V

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       G  V  P  G  A  G  I  P  V  V  P  G  A  G  I  P  G  A  A  V

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       A  R  P  G  V  G  V  G  G  I  P  T  Y  G  V  G  A  G  G  F

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      GGGTCGTGGACGGCAGATGGGGCAGGAGAGGTGCACAAGGCCCGCGCGACCGACGACGCT

        Q  E  L  P  S  T  P  S  S  P  R  V  P  G  A  L  A  A  A  K

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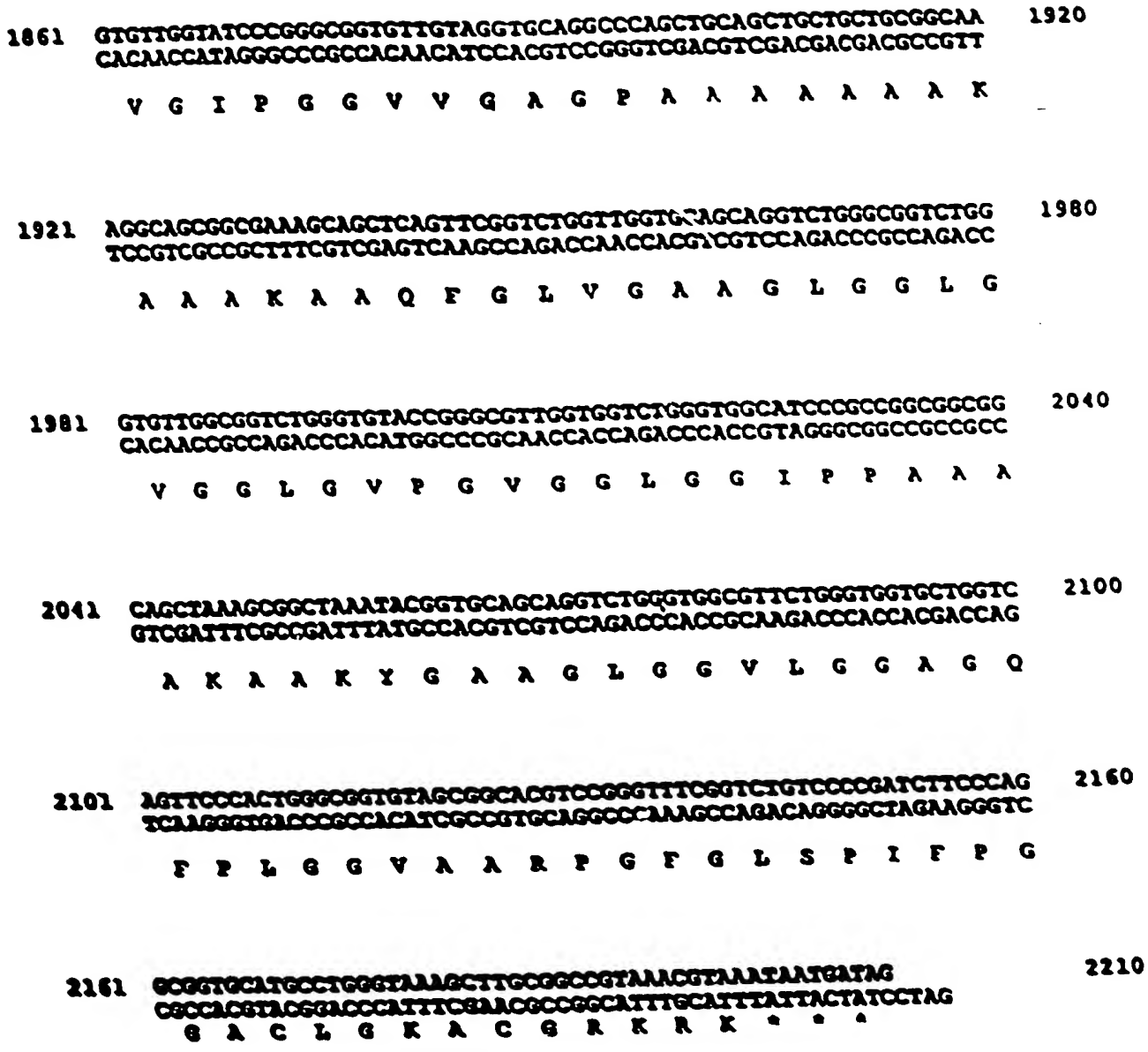
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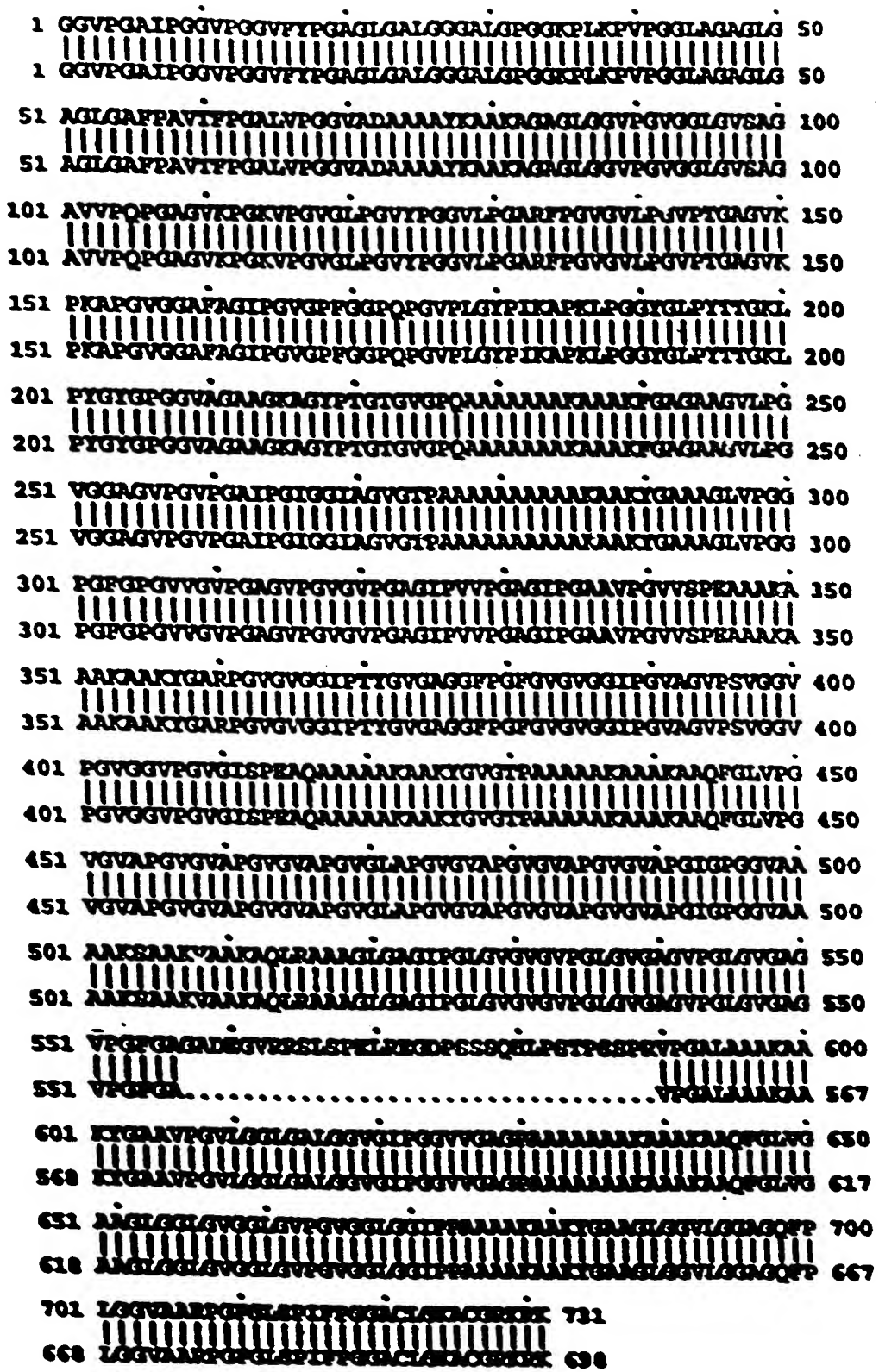
Figure 1(5)



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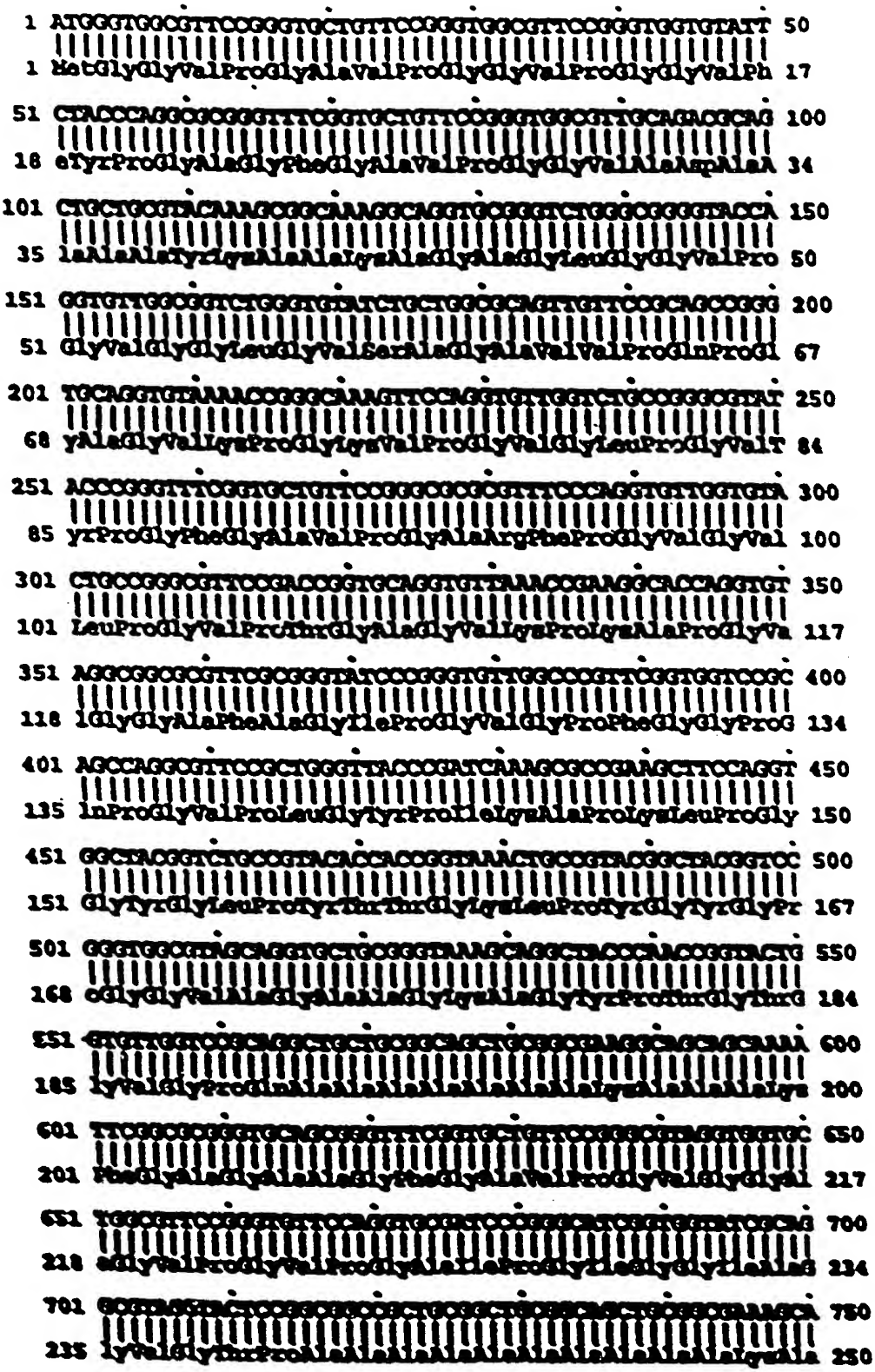

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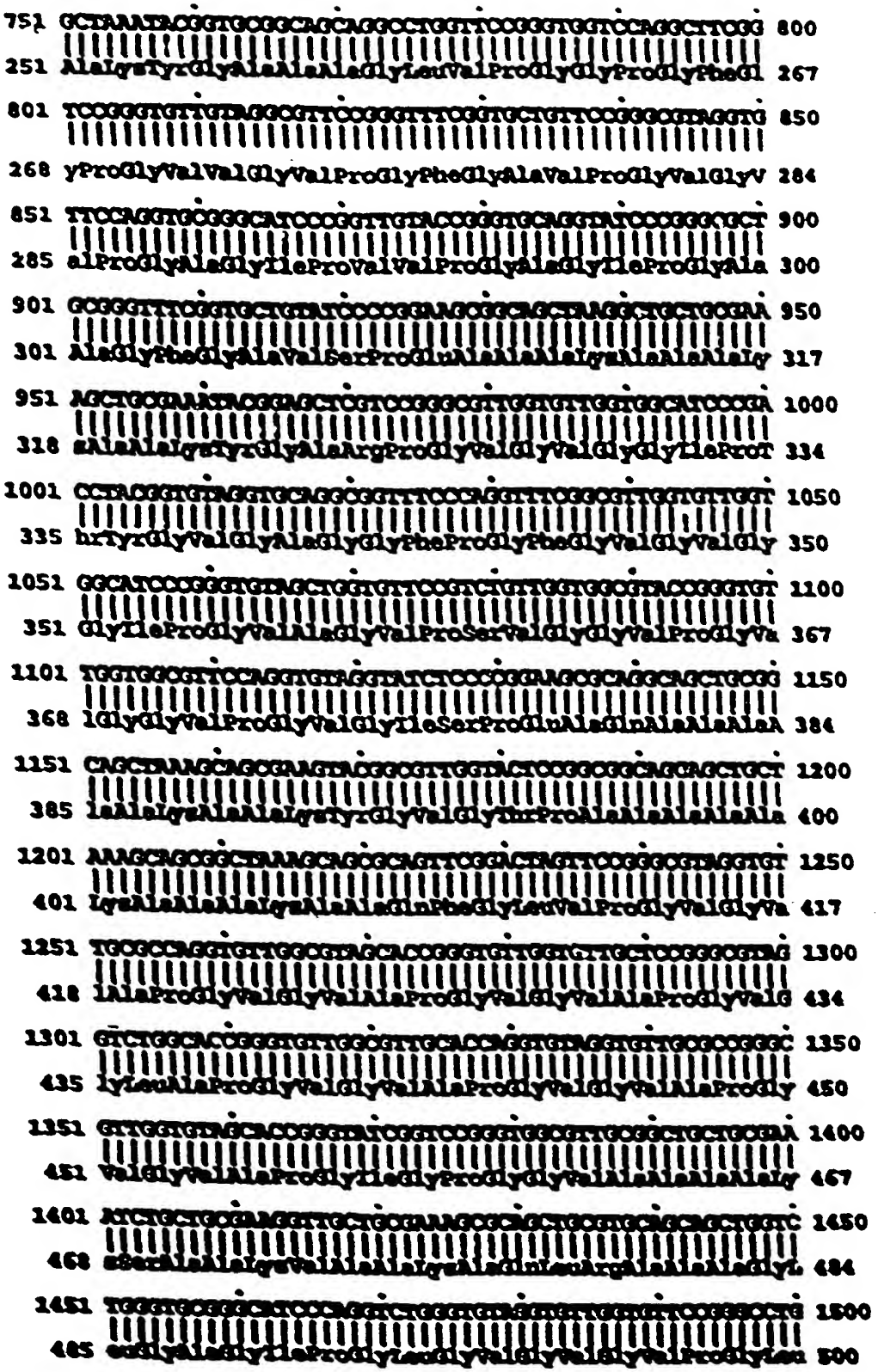

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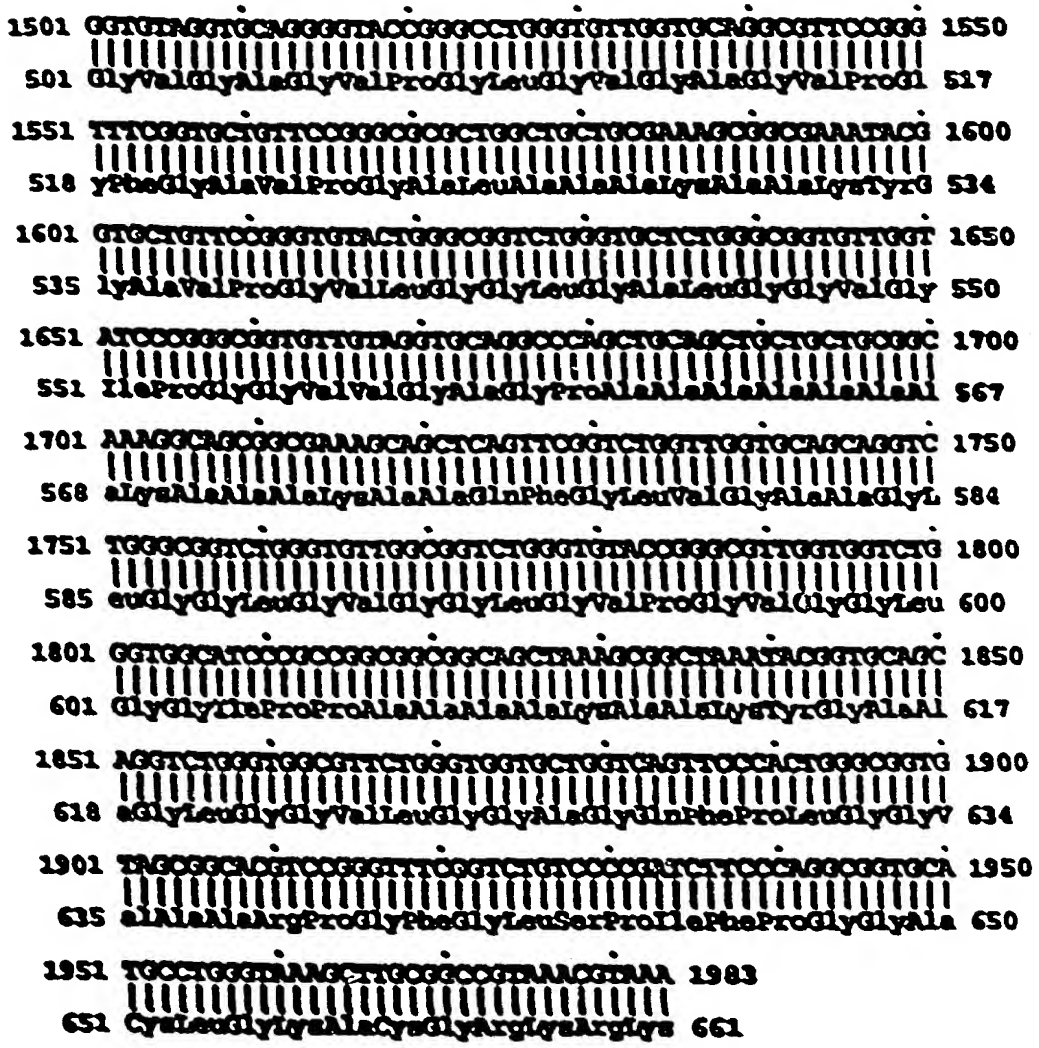

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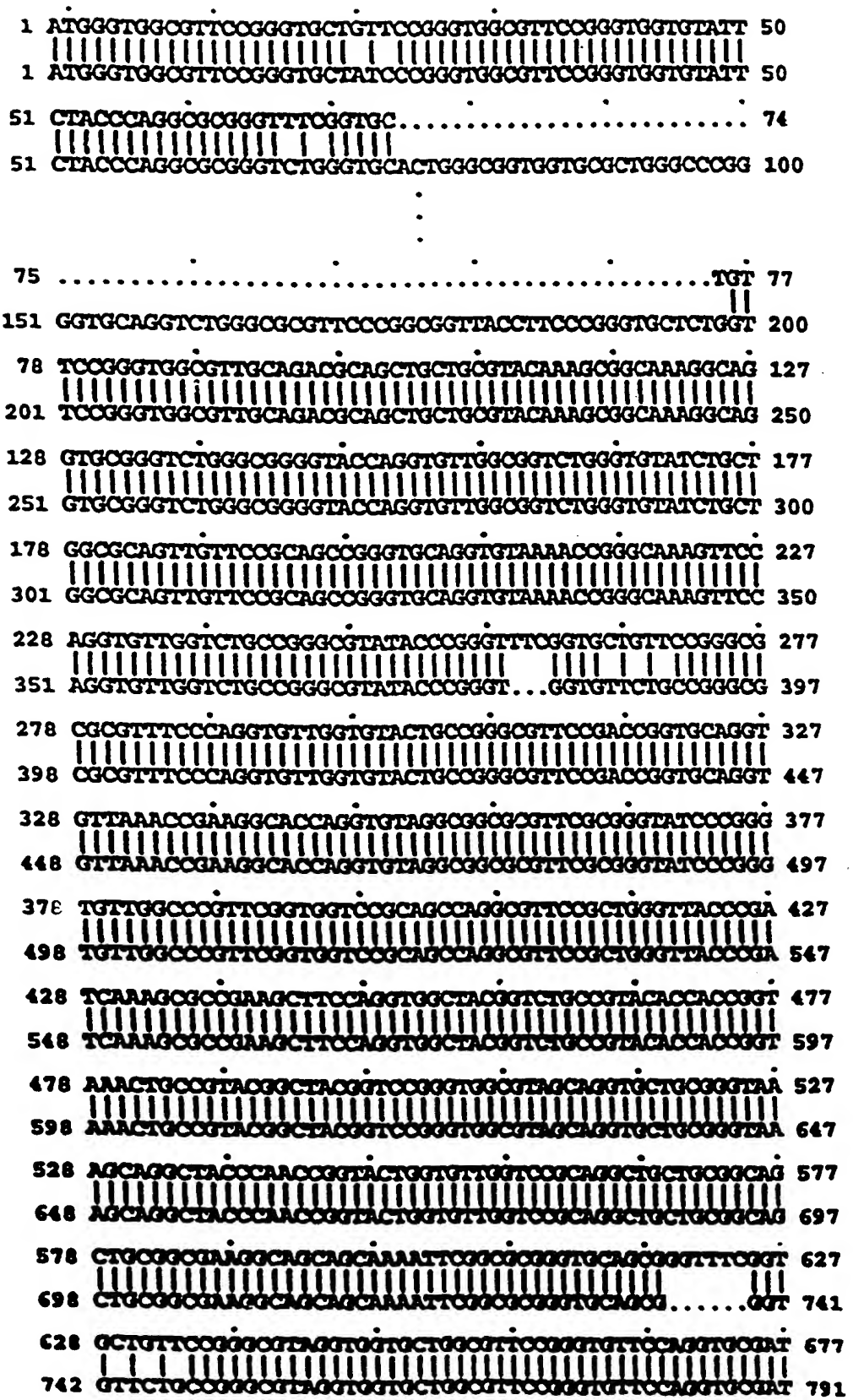
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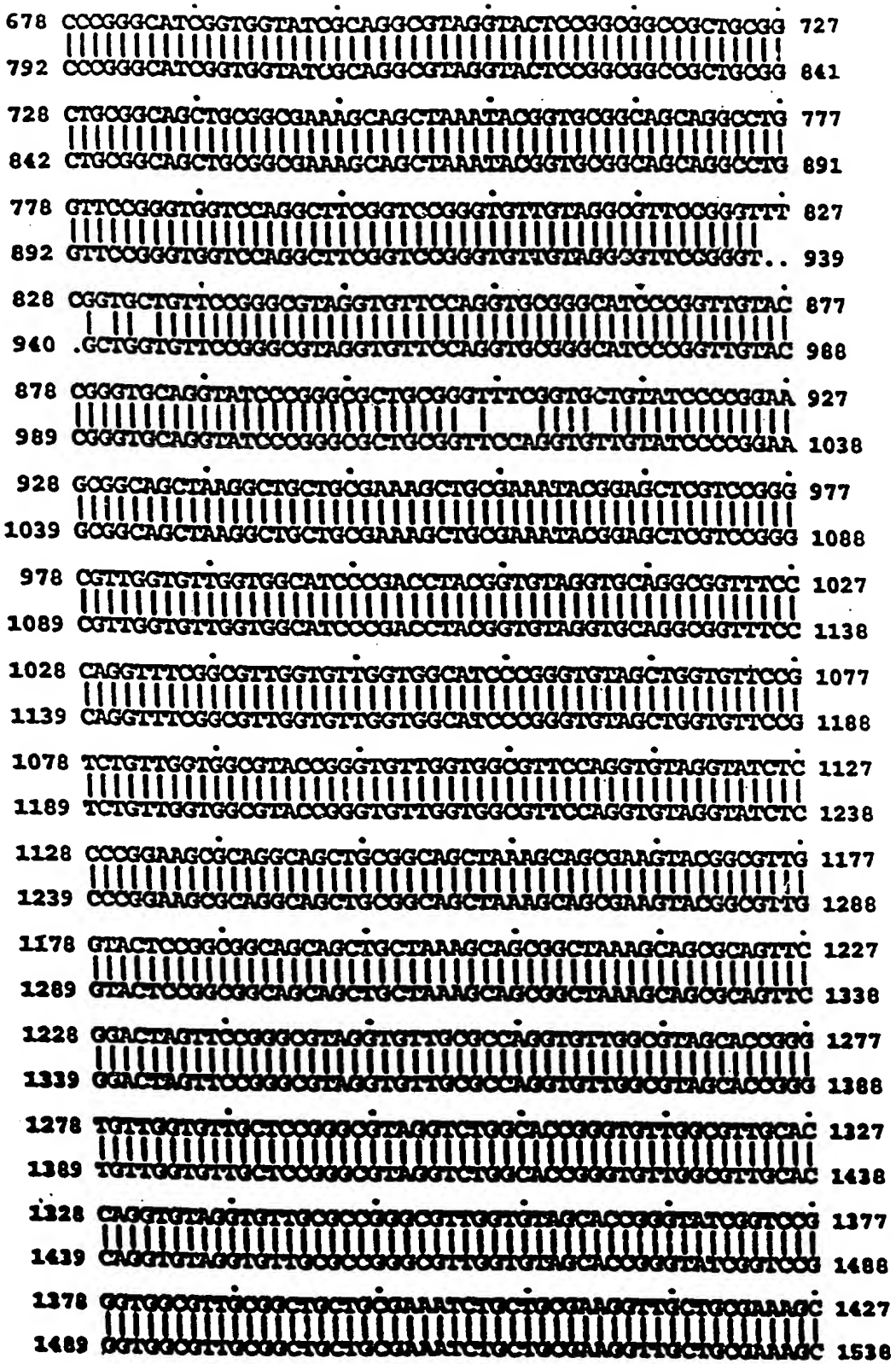
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Figure 4(2)

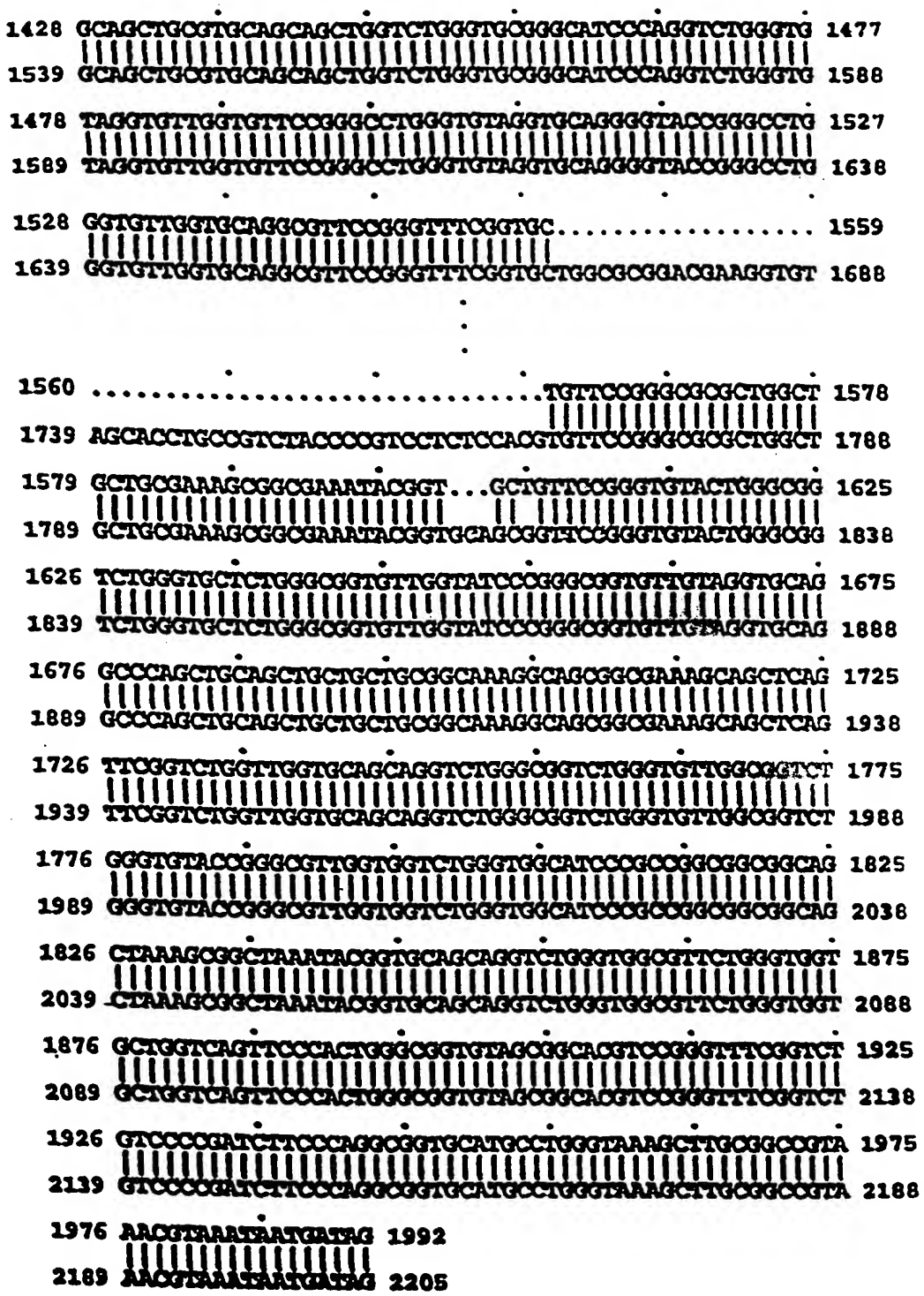
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Figure 4(3)

Figure 5(1)

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Figure 5(2)

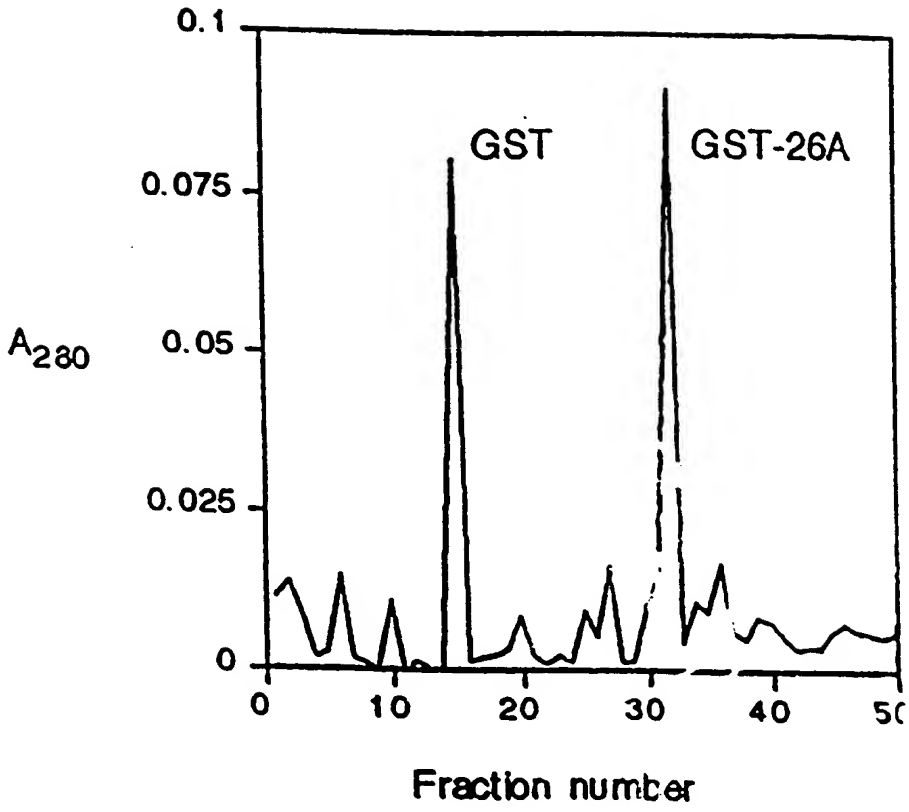
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Fig. 6(a)

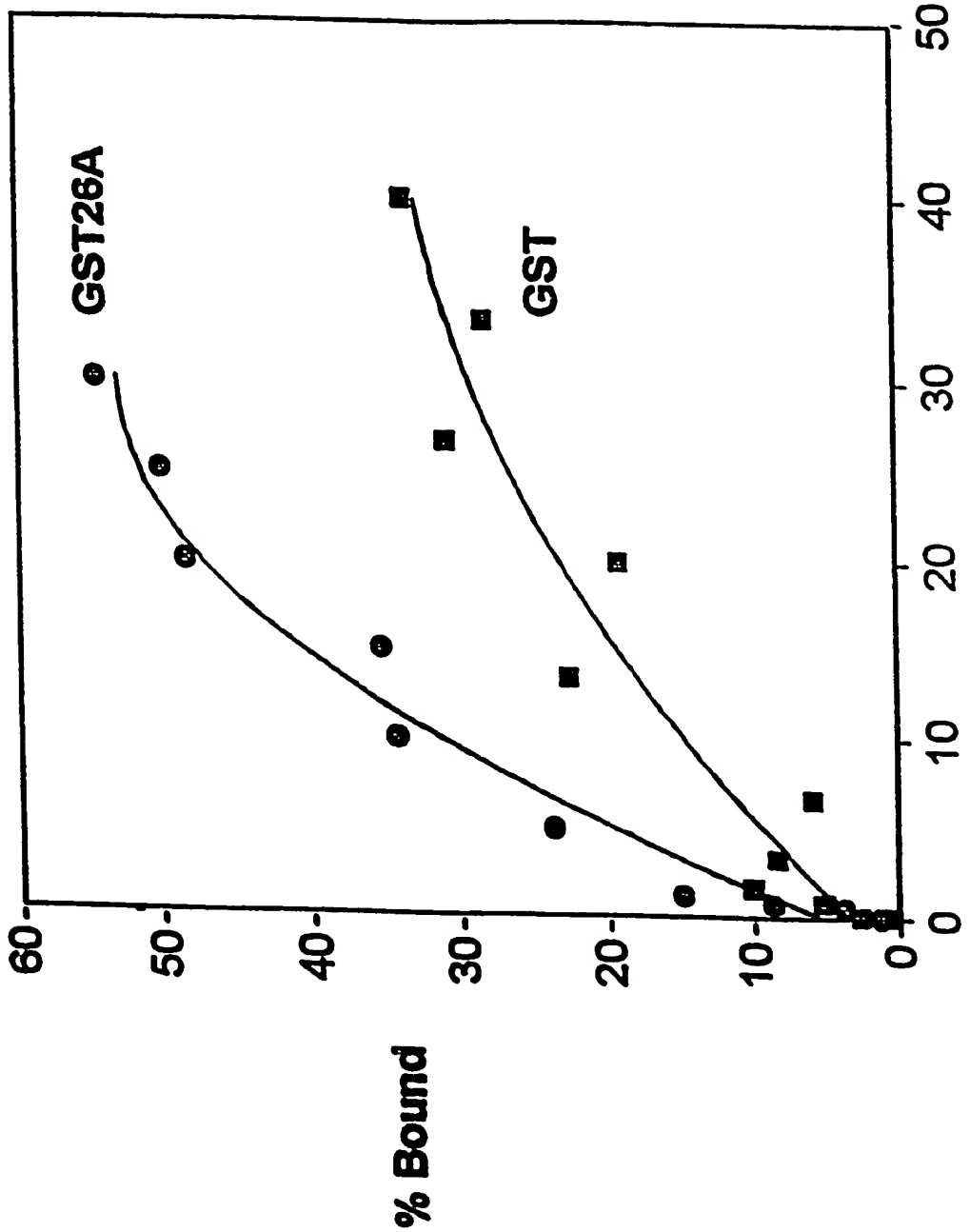

Fig. 6(b)

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998 ATACGGTGCAGCGGTTCCGGGTGTACTGGGCGGTCTGGGTGCTCTGGGCG 1047
    ||||||||||||||||||||||||||||||||||||||||||||||||||||
 18 sTyrGlyAlaAlaValProGlyValLeuGlyGlyLeuGlyAlaLeuGlyG 34

1048 GTGTTGGTATCCCGGGCGGTGTTGTAGGTGCAGGCCCAGCTGCAGCTGCT 1097
     ||||||||||||||||||||||||||||||||||||||||||||||||||||
  35 lyValGlyIleProGlyGlyValValGlyAlaGlyProAlaAlaAlaAla 50

1098 GCTGCGGCAAAGGCAGCGGCGAAAGCAGCTCAGTTCGGTCTGGTTGGTGC 1147
     ||||||||||||||||||||||||||||||||||||||||||||||||||||
  51 AlaAlaAlaLysAlaAlaAlaLysAlaAlaGlnPheGlyLeuValGlyAl 67

1148 AGCAGGTCTGGGCGGTCTGGGTGTTGGCGGTCTGGGTGTACCGGGCGTTG 1197
     ||||||||||||||||||||||||||||||||||||||||||||||||||||
  68 aAlaGlyLeuGlyGlyLeuGlyValGlyGlyLeuGlyValProGlyValG 84

1198 GTGGTCTGGGTGGCATCCCGCCGGCGGCGGCAGCTAAAGCGGCTAAATAC 1247
     ||||||||||||||||||||||||||||||||||||||||||||||||||||
  85 lyGlyLeuGlyGlyIleProProAlaAlaAlaAlaLysAlaAlaLysTyr 100

1248 GGTGCAGCAGGTCTGGGTGGCGTTCTGGGTGGTGCTGGTCAGTTCCCACT 1297
     ||||||||||||||||||||||||||||||||||||||||||||||||||||
 101 GlyAlaAlaGlyLeuGlyGlyValLeuGlyGlyAlaGlyGlnPheProLe 117

1298 GGGCGGTGTAGCGGCACGTCCGGGTTTCGGTCTGTCCCCGATCTTCCCAG 1347
     ||||||||||||||||||||||||||||||||||||||||||||||||||||
 118 uGlyGlyValAlaAlaArgProGlyPheGlyLeuSerProIlePheProG 134

1348 GCGGTGCATGCCTGGGTAAAGCTTGCGGCCGTAAACGTAAA 1388
     ||||||||||||||||||||||||||||||||||||||||
 135 lyGlyAlaCysLeuGlyLysAlaCysGlyArgLysArgLys 147
```

Figure 7

```
                .         .         .         .         .
948 TCCGCCATGGGAGCTCTGGTAGGCCTGGGCGTACCGGGCCTGGGTGTTGG 997
    ||||||||||||||||||||||||||||||||||||||||||||||||||
  1 SerAlaMetGlyAlaLeuValGlyLeuGlyValProGlyLeuGlyValGl 17
                .         .         .         .         .
998 TGCAGGCGTTCCGGGTTTCGGTGCTGGCGCGGACGAAGGTGTACGTCGTT 1047
    ||||||||||||||||||||||||||||||||||||||||||||||||||
 18 yAlaGlyValProGlyPheGlyAlaGlyAlaAspGluGlyValArgArgS 34
                .         .         .         .         .
1048 CCCTGTCTCCAGAACTGCGTGAAGGTGACCCGTCCTCTTCCCAGCACCTG 1097
    ||||||||||||||||||||||||||||||||||||||||||||||||||
 35 erLeuSerProGluLeuArgGluGlyAspProSerSerSerGlnHisLeu 50
                .         .         .         .         .
1098 CCGTCTACCCCGTCCTCTCCACGTGTTCCGGGCGCGCTGGCTGCTGCGAA 1147
    ||||||||||||||||||||||||||||||||||||||||||||||||||
 51 ProSerThrProSerSerProArgValProGlyAlaLeuAlaAlaAlaLy 67
                .         .         .         .         .
1148 AGCGGCGAAATACGGTGCAGCGGTTCCGGGTGTACTGGGCGGTCTGGGTG 1197
    ||||||||||||||||||||||||||||||||||||||||||||||||||
 68 sAlaAlaLysTyrGlyAlaAlaValProGlyValLeuGlyGlyLeuGlyA 84
                .         .         .         .         .
1198 CTCTGGGCGGTGTTGGTATCCCGGGCGGTGTTGTAGGTGCAGGCCCAGCT 1247
    ||||||||||||||||||||||||||||||||||||||||||||||||||
 85 laLeuGlyGlyValGlyIleProGlyGlyValValGlyAlaGlyProAla 100
                .         .         .         .         .
```

Figure 8(1)

```
1248 GCAGCTGCTGCTGCGGCAAAGGCAGCGGCGAAAGCAGCTCAGTTCGGTCT 1297
     ||||||||||||||||||||||||||||||||||||||||||||||||||
 101 AlaAlaAlaAlaAlaAlaLysAlaAlaAlaLysAlaAlaGlnPheGlyLe 117
          .         .         .         .         .
1298 GGTTGGTGCAGCAGGTCTGGGCGGTCTGGGTGTTGGCGGTCTGGGTGTAC 1347
     ||||||||||||||||||||||||||||||||||||||||||||||||||
 118 uValGlyAlaAlaGlyLeuGlyGlyLeuGlyValGlyGlyLeuGlyValP 134
          .         .         .         .         .
1348 CGGGCGTTGGTGGTCTGGGTGGCATCCCGCCGGCGGCGGCAGCTAAAGCG 1397
     ||||||||||||||||||||||||||||||||||||||||||||||||||
 135 roGlyValGlyGlyLeuGlyGlyIleProProAlaAlaAlaAlaLysAla 150
          .         .         .         .         .
1398 GCTAAATACGGTGCAGCAGGTCTGGGTGGCGTTCTGGGTGGTGCTGGTCA 1447
     ||||||||||||||||||||||||||||||||||||||||||||||||||
 151 AlaLysTyrGlyAlaAlaGlyLeuGlyGlyValLeuGlyGlyAlaGlyGl 167
          .         .         .         .         .
1448 GTTCCCACTGGGCGGTGTAGCGGCACGTCCGGGTTTCGGTCTGTCCCCGA 1497
     ||||||||||||||||||||||||||||||||||||||||||||||||||
 168 nPheProLeuGlyGlyValAlaAlaArgProGlyPheGlyLeuSerProI 184
          .         .         .         .         .
1498 TCTTCCCAGGCGGTGCATGCCTGGGTAAAGCTTGCGGCCGTAAACGTAAA 1547
     ||||||||||||||||||||||||||||||||||||||||||||||||||
 185 lePheProGlyGlyAlaCysLeuGlyLysAlaCysGlyArgLysArgLys 200
```

Figure 8(2)